European Commission

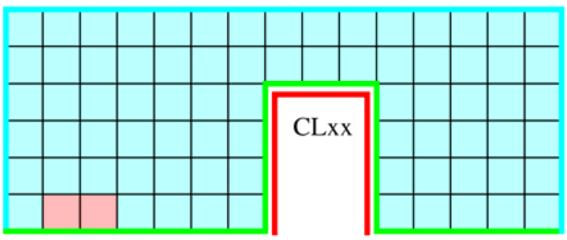
JRC TECHNICAL REPORTS

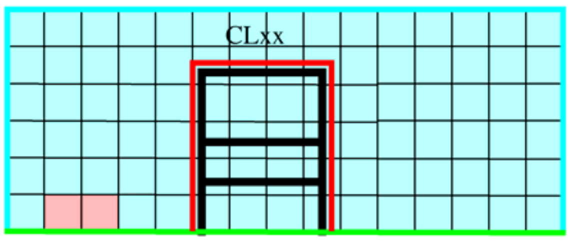
Visualization of Fluid-Structure Interaction Pressure acting on Structures with EUROPLEXUS

Folco Casadei
Martin Larcher
Georgios Valsamos

2015

Report EUR 27207 EN





Joint Research Centre

European Commission
Joint Research Centre
Institute for the Protection and Security of the Citizen

Contact information
Georgios Valsamos
Address: Joint Research Centre, Via Enrico Fermi 2749, TP 480, 21027 Ispra (VA), Italy
E-mail: georgios.valsamos@jrc.ec.europa.eu
Tel.: +39 0332 78 9004
Fax: +39 0332 78 9049

http://ipsc.jrc.ec.europa.eu/
http://www.jrc.ec.europa.eu/

This publication is a Technical Report by the Joint Research Centre of the European Commission.

JRC95654

EUR 27207 EN

ISBN 978-92-79-47751-5 (PDF)

ISSN 1831-9424 (online)

doi:10.2788/777426

Luxembourg: Publications Office of the European Union, 2015

Printed in Italy

JRC Technical Report

Pubsy N. JRC95654 - 2015

Visualization of Fluid-Structure Interaction Pressure acting on Structures with EUROPLEXUS

F. Casadei, M. Larcher, G. Valsamos
European Commission,
Institute for the Protection and Security of the Citizen
Joint Research Centre, 21020 Ispra, Italy

23 April 2015

Contents

List of Figures

List of Tables

1. Introduction

This report describes the implementation of a method for the visualization of fluid pressures acting on structures computed by various Fluid-Structure Interaction (FSI) approaches in EUROPLEXUS.

EUROPLEXUS [1] (EPX) is a computer code for fast explicit transient dynamic analysis of fluid-structure systems jointly developed by the French Commissariat à l'Energie Atomique (CEA Saclay) and by the Joint Research Centre of the European Commission (JRC Ispra).

EPX offers a rich variety of FSI models, ranging from classical conforming-mesh approaches based on the Arbitrary Lagrangian Eulerian (ALE) formulation, to models of the embedded (or immersed) type, where the structure and fluid meshes are completely independent, see [2] for a summary.

This document is organized as follows:

- Section 2 describes the problem and analyzes several possible types of visualization available with the standard tools offered by EPX, depending on the type of approach to FSI (embedded or not embedded).
- Section 3 proposes a new type of visualization which standardizes the rendering of FSI pressures for all types of approach available in EPX.
- Finally, Section 4 shows a series of numerical examples.

The Appendix contains a listing of all the input files mentioned in the present report.

2. FSI pressure visualization

EPX is often used to perform simulations of complex Fluid-Structure systems under transient conditions. A typical example is an explosion within or outside a building. Pressure waves are generated by the explosive (or by a pressurized tank which suddenly fails), are propagated in a fluid medium (typically the atmosphere) and impact some surrounding structures, whose behavior is the main outcome of the investigation.

While EPX is a fully-functional FSI code, in which the structure behavior under transient pressure loading can be directly simulated even up to failure and fragmentation of the structure, sometimes it is desirable, e.g. for comparison with other codes or with semi-analytical approaches, to treat the structures (typically some critical buildings) as rigid, and to study only the fluid domain, i.e. the transmission and reflection of pressure waves which, in complex 3D geometries, can be quite complex. This is the typical approach of purely CFD codes.

Then, the desired output from an EPX simulation is the fluid pressures acting on the building walls, as a function of space (spatial distribution over the walls, which is typically highly non-uniform) and of time. This approach of course neglects any feedback effect on the fluid flow due to the motion and deformation of the structure, but it is appropriate provided the structures are very stiff, so that they can be considered as completely rigid in a first approximation.

In the following, we briefly consider how to obtain the desired pressure map results in the various cases, that is with the various FSI approaches available in EPX, and propose a unified approach, mainly for simplicity reasons, i.e. to facilitate and standardize this type of analysis by users of the code. We consider the problem outlined above, i.e. an explosion in a fluid domain, bounded by, or containing, some rigid and blocked structures. However, the solution proposed will be applicable also to cases where the structure is deformable.

2.1 Fluid-only simulations

If the structures of interest are very thick and massive, they can be assumed as rigid and in principle there is no need to include them in the numerical model, which contains only the fluid domain. This approach is sketched below in Figure 1 (the sketch is 2D for simplicity, but one can easily imagine the situation in 3D).

In the numerical model only the fluid domain is included. Note that (for an external explosion) the fluid contained inside the building is not included, since the building is rigid. The fluid domain has the irregular shape shown in the right picture, in practice a regular (rectangular) domain with a “hole” in it at the location of the building. The fluid boundary is divided in two regions. The upper

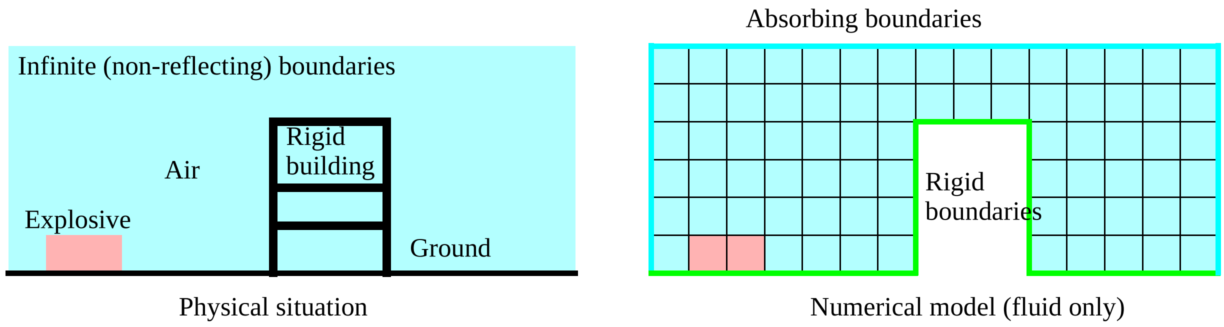


Figure 1 - Fluid-only simulation of an explosion near a rigid building

part of the boundary is an absorbing (non-reflecting) boundary (modelled in EPX by attaching special CLxx elements to it, not shown in the picture for simplicity) which simulates the presence of an infinite atmosphere. The lower part of the boundary (in green) is a rigid (perfectly reflecting) boundary. Note that this includes both the soil and the contour of the building.

One way of visualizing the "pressure on the building" (or on the soil) in this type of situation is to look at the fluid boundary by activating the visualization of fluid pressure in the form of an iso-value map, as sketched in Figure 2.

To obtain the desired effect, one should in principle adopt the scene settings shown in the left picture (for full details about the setting of a scene for visualization of results in EPX see the User's manual [1], logical page O.80):

- The observer's position (eye) should be placed <u>inside the fluid domain</u>, and should point towards the structure of interest.
- The visualization of <u>back faces</u> of the fluid domain should be activated (the visualization of front faces is active by default).
- The visualization of iso-values of the pressure (typically located in ECR(1) for fluid materials) in the form of iso-fill or iso-fill with lines should of course be activated.

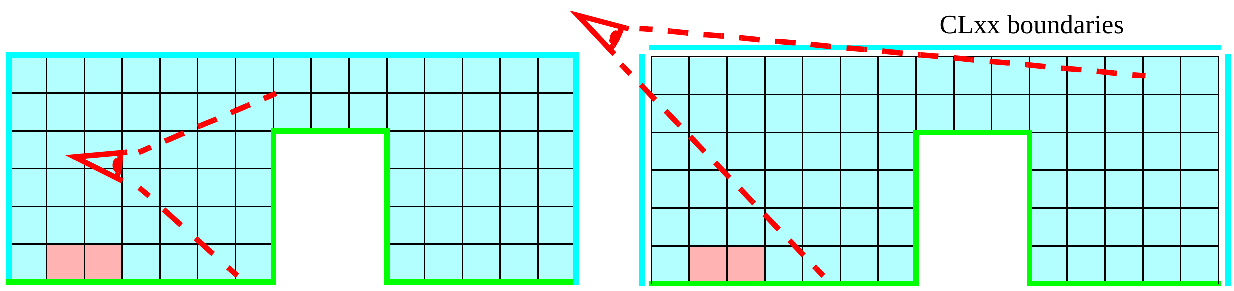


Figure 2 - Visualization of fluid pressure map on the fluid boundary

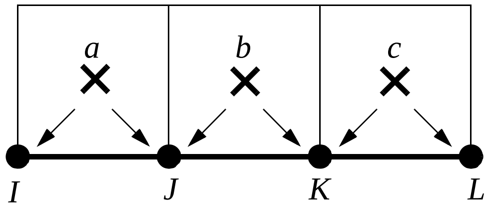


Figure 3 - Construction of the iso-values map

However, it should be noted that, if CLxx (boundary-condition) elements are used (as is customary) in EPX to apply the absorbing conditions, then the first requirement above is not really necessary. In other words, the position of the eye can also be outside the fluid domain.

The reason for this apparently strange behavior of the visualizer, which is very useful in this particular case, is the following (see right picture above). When a CLxx element is attached to the boundary of a “continuum” element like the fluid element, so that the two elements share the same nodes, then the common face of the two elements is considered as “internal” (not external), since it belongs to both elements (the fluid element and the CLxx element).

Then, since internal faces of the mesh are not visualized by default, the result is that the fluid absorbing boundary and the CLxx magically “disappear” from (or are shown as transparent in) the scene, so that one can see “inside” the fluid domain even from an outside position.

The iso-values map on the “external” faces of the fluid domain (those without any neighbor) are built as follows, see Figure 3. For either Finite Element (FE) or Cell-Centred Finite Volumes (VFCC) discretizations of the fluid domain, the pressure value in each element (or volume) is located at the centroid of the element: let the values be p_a, p_b, p_c as shown in the example of Figure 3. First, nodal values of the pressure on the nodes of the external faces of the fluid domain (I, J, K, L in the example) are built up as arithmetic averages of the elemental values for all the elements neighboring each node. For example, in Figure 3 we would have $p_J = (p_a + p_b)/2$. Then, the nodal values are used to build up the iso-map. This process of averaging (or projection) introduces some smoothing on the resulting iso map, but this is usually not a problem.

Note that EPX also offers Node-Centred Finite Volumes (NCFV) for the discretization of the fluid domain. In that case, the pressure values are already discretized at the nodes, so the preliminary projection (averaging) of elemental values is not needed.

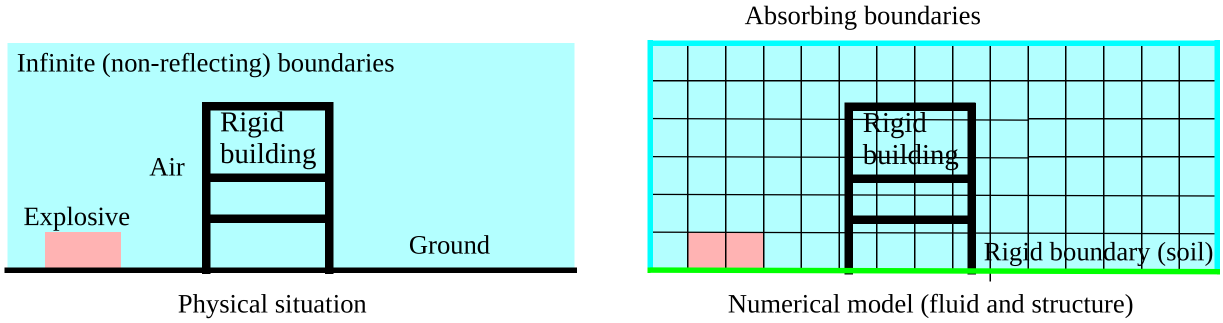


Figure 4 - Fluid-structure (embedded) simulation of an explosion near a rigid building

2.2 Simulations with fluid and (embedded) structure

Another approach which can be taken in EPX is to embed (or immerse) the structure in the fluid. In this case, the fluid and structure meshes are completely independent, see Figure 4. This approach has several advantages with respect to the one considered in the previous Section:

- The construction of the fluid mesh is simpler, since one can take just a regular domain (a rectangle in the example considered here).
- The structure is allowed to undergo arbitrarily large motions and rotations, and it can even fail and be replaced by flying debris. This is not the case in the present example, but it would be an important advantage if later on one decides to model the building as deformable.

Of course, there are also some drawbacks:

- We have to model a structure (which in principle would be unnecessary in this case), and we must block all degrees of freedom of the structure in order to represent it as rigid.
- Since there is no well-defined fluid boundary near the structure, the visualization of iso-maps on such a boundary is less straightforward than in the previous case.

Note that in the embedded approach, the whole physical fluid domain is included in the model, including the air contained within the building.

In this case the direct visualization of the "fluid pressure on the building walls" is of course more difficult than with the previous approach. Note in fact that the structural walls do not coincide, in general, with an interface between two fluid elements. So, we normally do not have in the fluid domain a geometrical support on which the desired iso-values could be shown.

An approximate visualization of the iso-map can in some cases be obtained as shown in Figure 5. If the VFCC method is used to discretize the fluid domain, the embedded FSI model is called the FLSW model, see reference [2] and the User's manual [1] for details.

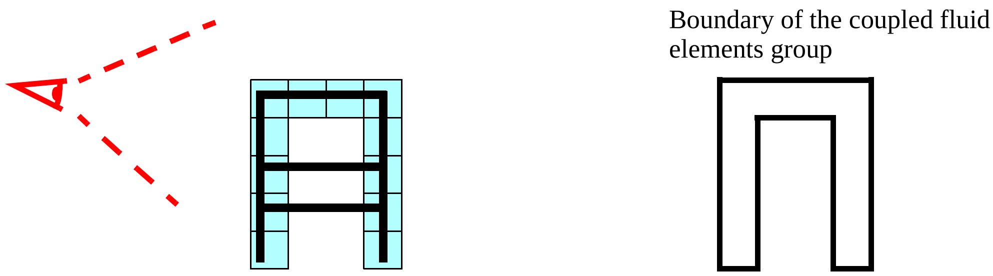


Figure 5 - Visualization of fluid pressure map on boundary of the “coupled” fluid

In such a case the code builds up automatically a group of elements named “_FLSW” (note the leading underscore in the name, indicating an automatically built group) which contains all fluid elements (volumes, in this case) currently “coupled” with the structure. If one chooses to visualize only this portion of the fluid mesh, and then activates iso-values representation of the pressure, one will see the pressure values on the surface of the coupled fluid elements (see right picture). In fact, since only these elements are shown, their faces are considered as “external” wherever there is no neighbor element belonging to the chosen group.

Of course this is not an exact representation of the building surface (we see this surface with an approximation of one fluid element) but it might be sufficiently accurate, especially if the size of the fluid mesh is small. The fluid mesh can be refined by activating automatic fluid mesh adaptivity near the structure (optional ADAP keyword in the FLSW directive, see User’s manual [1]).

3. New type of visualization

The visualization types proposed in the previous Section may be adequate and sufficient in some cases, but require a know-how and some care since they depend upon the specific FSI model used in the numerical simulation.

Here we propose a new approach for the visualization of FSI-related fluid pressures, which can be used in conjunction with all FSI models available in EPX and is therefore simpler and more consistent to use.

3.1 The IMPE VISU approach

The basic idea is to define a dedicated geometrical support in order to visualize the desired iso-value maps. We will use CLxx (surface) elements for this purpose. If a fluid-only approach is chosen, then the CLxx elements will be attached to the surface of the fluid elements adjacent to the structure (which, however, is not included in the model), see the left part of Figure 6. If an embedded FSI model is used, then these dedicated CLxx elements will be attached to those portions of the structure surface on which the pressures (or other quantities of interest) should be visualized, as shown in the right part of Figure 6.

Note that the structure might be meshed by continuum elements (although typically shell elements are used for efficiency reasons). By using a layer of CLxx elements, we standardize the visualization approach, which becomes independent of the discretization chosen for the structure.

In any case (embedded or not), the CLxx elements give an "exact" (discrete) representation of the structure surface of interest, with the same resolution as the structure mesh. In particular, if mesh adaptivity is applied to the structure, the CLxx attached elements will also be adapted accordingly, in a fully automatic way.

Each CLxx element has a single Gauss point (at its centroid) and therefore admits only one value for each quantity of interest. The iso-maps on the CLxx domain are built with the technique shown

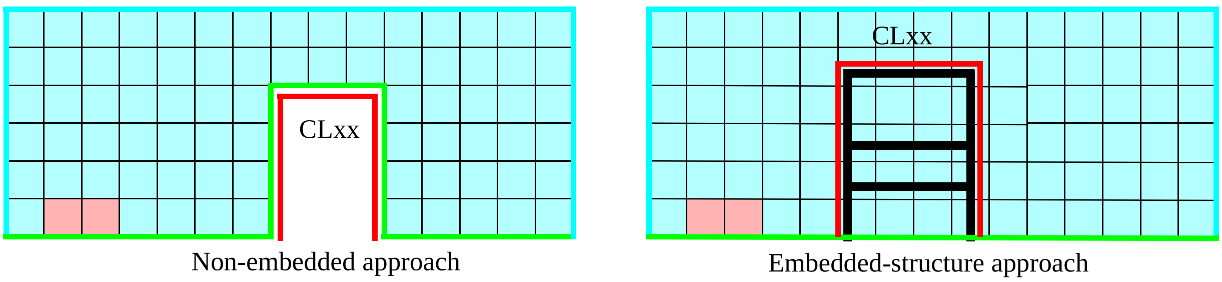


Figure 6 - Dedicated CLxx elements with IMPE VISU material

above in Figure 3: first nodal projected (averaged) values are built up, and then the iso map is constructed.

A new type of impedance “material” (IMPE VISU) is introduced in EPX, which serves just for visualization purposes. Each CLxx element possessing this material will collect the quantities of interest at its Gauss point (in the ECR table), thus opening the way to iso-value visualizations in the standard ways offered by EPX.

The problem is then how to store the desired values in the CLxx elements. In the fluid-only case, this is straightforward: a CLxx element a “inherits” the FSI pressure value p_a (or other quantities of interest) from the fluid element (or volume) i to which it is attached, see Figure 7:

$$p_a = p_i - p_{i,\,\mathrm{ref}} \tag{1}$$

where p_i is the absolute pressure and $p_{i,\,\mathrm{ref}}$ is the reference pressure in the fluid element.

In the embedded case the matter is more delicate. The CLxx element is attached to the structure in this case, and there is no straightforward way of determining which is the fluid element “nearest” to it. If the fluid mesh is finer than the structure, there are typically several fluid elements “close” to a single structural element.

Even if the fluid elements “near” a structural element could be readily determined, there is no clear way of how to “inherit” values from such elements. These fluid elements are often cut by the structure and lie partly on one side of the structure (e.g., exterior), partly on the other side (e.g., interior). The value of pressure in one such element is not representative of the pressure acting on the wall, nor of the pressure on either side of it. One should move at least one element away to get a more physical pressure value, but this is complicated to do in practice. Furthermore, the technique would heavily depend on the particular embedded FSI algorithm used: FLSR (for FE) or FLSW (for VFCC).

Therefore, a different approach seems preferable, one which is much more general and, most importantly, <u>inherently consistent</u> with the FSI model chosen. The idea is to reconstruct the “effective” pressure field acting on the structure surface by using the result of the (of any, in fact) FSI algorithm: the <u>interaction forces</u> that the fluid exerts on the structure.

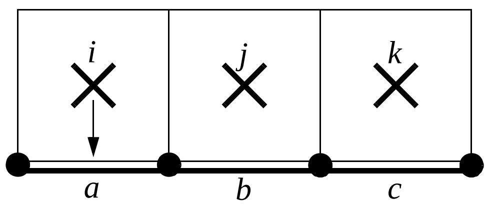


Figure 7 - Inheritance of FSI pressure field from the neighboring fluid element

In a FE approach, using the FLSR algorithm for FSI, these forces are obtained by a "strong" approach based upon Lagrange multipliers (LINK COUP directive in EPX) and are contained in the FLIA table. In a VFCC approach, using the FLSW algorithm, the interaction forces are obtained by a "weak" approach based upon direct application of fluid pressure drop on the structural walls (LINK DECO directive in EPX), and are contained in the FDEC table. In both cases, at each node a vector (three component in 3D) is known, which contains both the intensity and the direction of the interaction force.

A possible algorithm to achieve this goal is as follows (see Figure 8). Let I be the node of interest, This node belongs to the structure, and therefore the interaction force $\vec{F}_I$ acting on it is known. The node belongs also to some CLxx elements with the IMPE VISU material, elements a and b in the example, of areas A_a, A_b and of unit normals $\vec{n}_a$, $\vec{n}_b$. We want to estimate the "effective" FSI pressure p_I acting on (or in the vicinity of) node I. This can be obtained from the relation:

$$p_I = \frac{F_{I\perp}}{A_I} \tag{2}$$

where A_I is the "area of influence" associated with node I, i.e. the area of the surface on which the FSI pressure is acting. In the example of Figure 8 this is given by:

$$A_I = A_{aI} + A_{bI} \tag{3}$$

where A_{aI}, A_{bI} are the portions of the areas A_a, A_b of the CLxx elements "associated" with node I. The quantity $F_{I\perp}$ appearing in (2) is the projection of the nodal force vector $\vec{F}_I$ along "the" normal to the surface formed by the CLxx elements at node I, which can be approximated as:

$$F_{I\perp} = \frac{(\vec{F}_I \cdot \vec{n}_a)A_{aI} + (\vec{F}_I \cdot \vec{n}_b)A_{bI}}{A_{aI} + A_{bI}} \tag{4}$$

Note that, since $F_{I\perp}$ is a signed scalar quantity, and A_I is a positive scalar, then p_I is a signed scalar quantity.

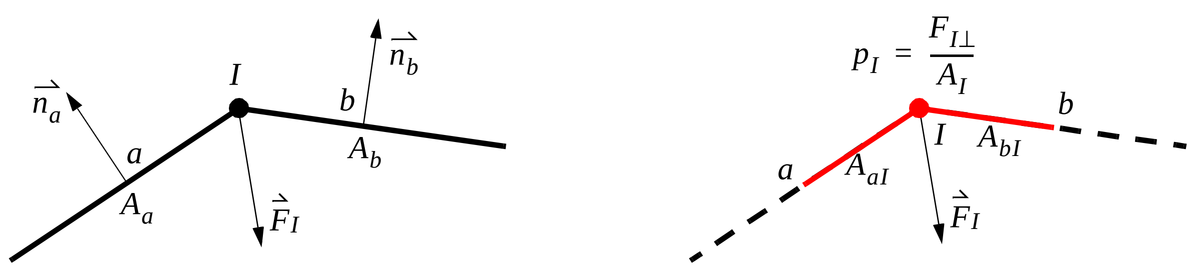


Figure 8 - Reconstruction of FSI pressure field from the interaction forces

3.2 Potentially problematic cases

This algorithm is expected to give a good approximation of the FSI pressure acting in the vicinity of each node, except in the following situations with the embedded approach, sketched in Figure 9:

- Near a contour of the CLxx domain which does not coincide with a contour of the structure surface (left picture). At node I the FSI force vector includes contributions from two structural elements (i and j), but the CLxx area considered includes only the contribution of element a.
- In the presence of junctions in the structure (right picture). At node J the FSI force includes contributions from three structural elements (k, l and m) while the CLxx area includes the contributions of elements b, c and d (only if the latter is present).
- In the presence of a strong curvature of the structure.

The first situation can usually be avoided by a careful choice of the region on which the pressures should be visualized. The other two, if present, are inevitable and then some care is needed in the interpretation of results.

Finally, another possible source of trouble with the use of IMPE VISU in the embedded case is when the structure is subjected also to other conditions, besides those related to FSI, for example in the presence of blockages, symmetry conditions, etc. (bottom picture), when all conditions are imposed by the same method (either strong or weak). In fact, in such cases the nodal forces will contain both contributions from FSI and contributions from the other conditions, see e.g. node K in the bottom picture which is subjected both to FSI and to a blockage. Since the effects cannot be separated, the evaluation of FSI pressure will be wrong in the nodes subjected to multiple conditions. This problem can be avoided by using different methods, for example weak formulation (LINK DECO FLSW) for the FSI and strong formulation (LINK COUP BLOQ) for the blockages.

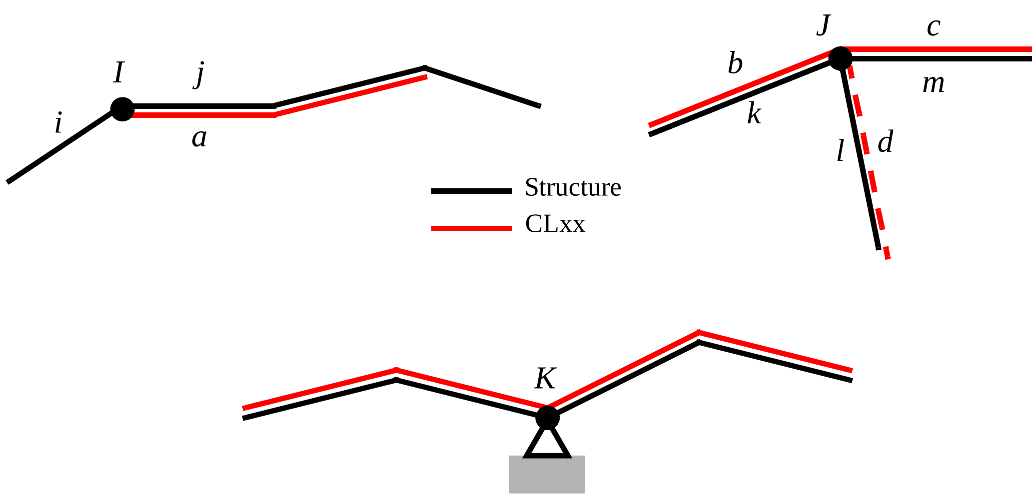


Figure 9 - Cases to be handled with care

4. Numerical examples

We now present some numerical examples in order to check the IMPE VISU model that has been described in the previous Section.

4.1 Fluid-only simulations

We first consider fluid-only simulations. In this case, the CLxx elements with associated material IMPE VISU must be attached directly to the (external) faces of the fluid domain. The simulations performed are summarized in Table 1.

Case	Type	Fluid	CLxx	Notes
VISU03	Fluid only	CUVF/GAZP	CL3Q	Base calculation
VISU05	Fluid only	CUVF/GAZP	CL3Q	INIT ADAP
VISU06	Fluid only	CUVF/GAZP	CL3Q	ADAP SPLI OBJE after 20 steps

Table 1 - Fluid-only simulations

VISU03

A fluid box measuring $8 \times 6 \times 6$ units has absorbing boundaries all around except along its bottom, which is a rigid boundary (soil). Inside the box there is a rigid building of dimensions $3 \times 3 \times 4$ units, attached to the ground. The building is not included in the model. The volume of the building is “subtracted” from the volume of the fluid box so as to leave a “hole” in it.

Boundary condition elements CL3Q are placed along the lateral walls and along the roof of the fluid box, to simulate absorbing boundaries (via a CLVF ABSO material). We are interested in the FSI overpressure acting on the building. Therefore, we attach CL3Q elements also to the fluid surface in contact with the (imaginary) building, and assign an IMPE VISU material to these elements.

An explosion takes place near the origin (a corner of the fluid box), simulated by gas at initially higher pressure and density than normal atmospheric values.

Some results of this calculation are presented in Figure 10. Solutions at 10 and 100 steps are shown. On the left is shown the FSI pressures (overpressure) acting on the building, by means of the IMPE VISU technique. On the right, for comparison, is shown the (absolute) fluid pressure acting on the back faces of the fluid domain, by using the standard technique described in Section 2.1 (Figure 2).

The results look similar, but there are some notable differences, which are explained next:

- In the IMPE VISU visualization only the building object is shown, because the CLxx elements with the IMPE VISU material are attached only to this zone of the fluid mesh. In the standard visualization, also the “soil” is visible, since it is also part of the “back” faces of the fluid domain.

Of course it would be possible, if so preferred, to visualize the pressure on the soil also with the IMPE VISU technique, by simply attaching additional CLxx elements to the fluid surface in contact with the soil.

- Pressure results in the two visualizations are identical at all nodes “internal” to a face of the building, while there are differences at the nodes located along the corners of the building box. This is due to the fact that in one case all fluid elements around the corner (3 elements) participate in defining the fluid pressure “at the corner”, while in the other case only two elements participate, those adjacent to the faces. These differences are relatively small and can only be observed because the resolution of the mesh is extremely coarse. In a more realistic case, with a much finer discretization, the differences would become almost unnoticeable.

It should also be noted that the scale of the pressure values in the two visualizations is intentionally not the same, in order to be able to directly compare the results. In fact, the IMPE VISU model visualizes the FSI pressures, i.e. the overpressures with respect to the reference pressure (which is 1 bar in this example) according to equation (1), while the standard model visualizes the absolute fluid pressures. Therefore, the scale for the left images goes from -0.4 to 2.2 bar, while the scale for the right images goes from 0.6 to 3.2 bar (with a difference of exactly 1.0 bar in each value).

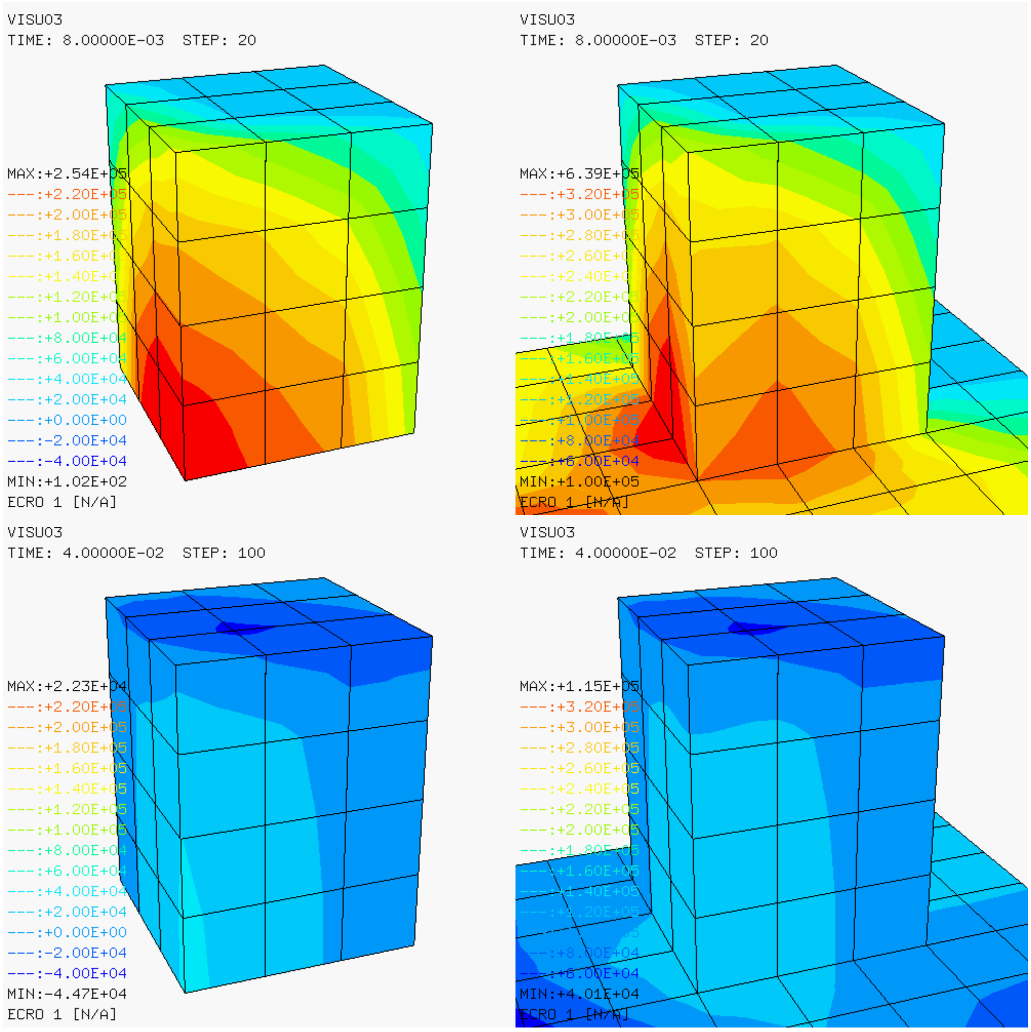
The FSI overpressure is contained in the ECR(1) for the IMPE VISU material. The absolute pressure is also (usually) contained in ECR(1) for most fluid materials.

Next (Figure 11), we present some further results that can be obtained with the IMPE VISU material. ECR(2) contains the maximum FSI overpressure ever registered at each point during the transient calculation, while ECR(3) contains the minimum FSI overpressure (i.e. the maximum underpressure). We show these two maps at the final step of the calculation. Note that the color map is inverted in the maximum underpressure map (right picture), so that the red color indicates the maximum (in absolute value) underpressure.

VISU05

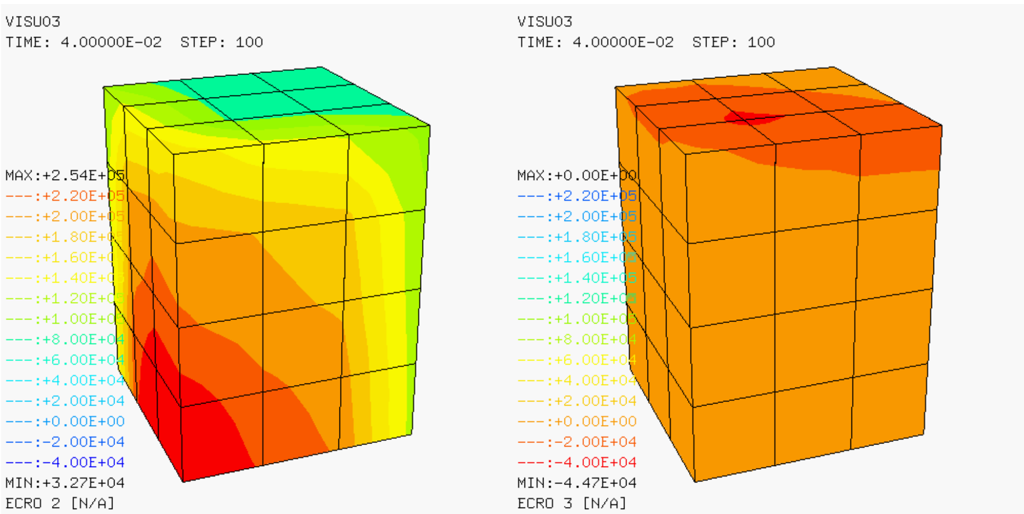
Next, we want to check the IMPE VISU model in case of adaptivity in the fluid mesh. The test case VISU05 is similar to VISU03 but we refine the fluid mesh at the initial time (and then we keep it constant throughout the simulation) by means of the INIT ADAP directive. The fluid mesh zone to be refined is identified in Cast3m when building up the mesh as the locus of all (base) fluid elements attached to the (imaginary) building, i.e. attached to the `visu` object, composed of CL3Q elements, that is associated with the IMPE VISU material.

The results of this calculation are shown in Figures 12 and 13, to be compared with Figures 10 and 11, respectively.



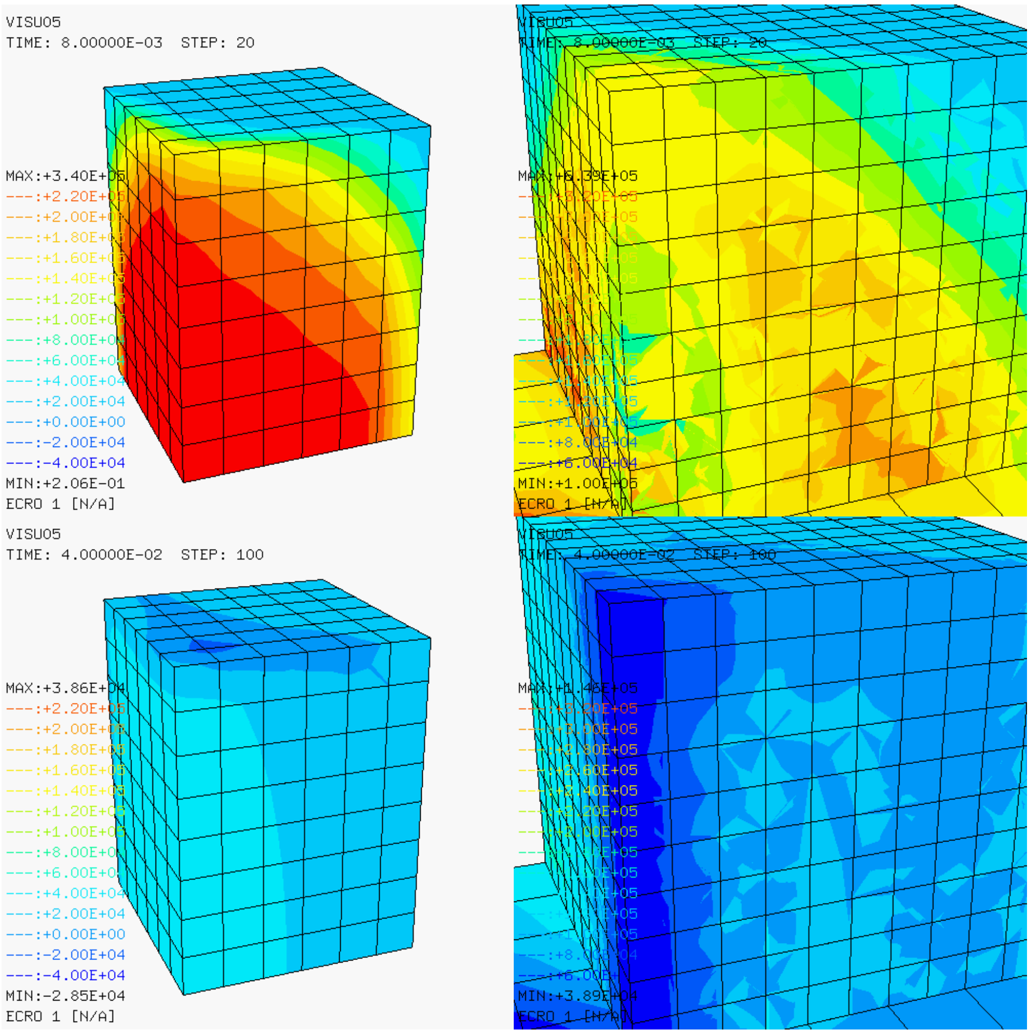
Visualization via IMPE VISU — Standard visualization

Figure 10 - Fluid pressures on the building in case VISU03



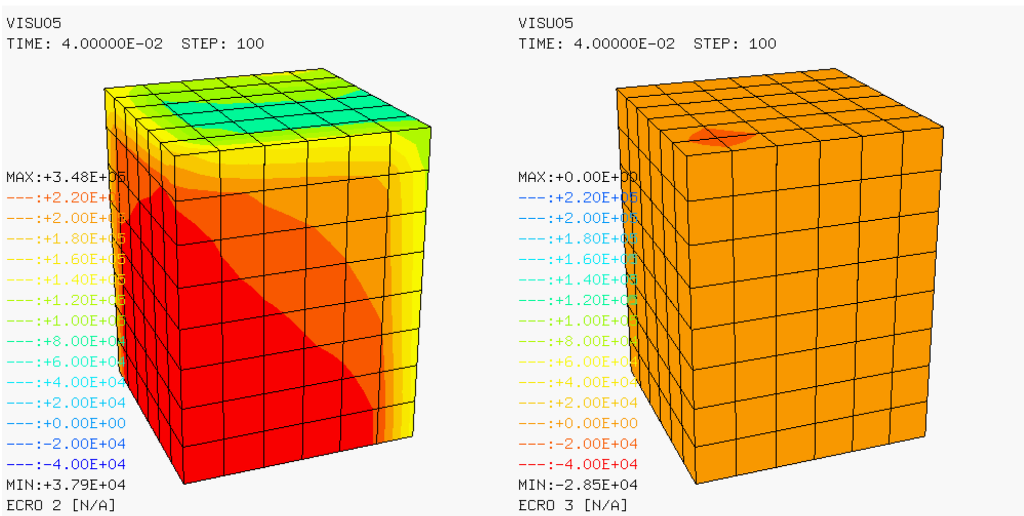
Maximum FSI overpressure — Maximum FSI underpressure (inverted colors)

Figure 11 - Maximum and minimum FSI overpressure maps in case VISU03.



Visualization via IMPE VISU　　　　　Standard visualization

Figure 12 - Fluid pressures on the building in case VISU05



Maximum FSI overpressure　　　　　Maximum FSI underpressure (inverted colors)

Figure 13 - Maximum and minimum FSI overpressure maps in case VISU05.

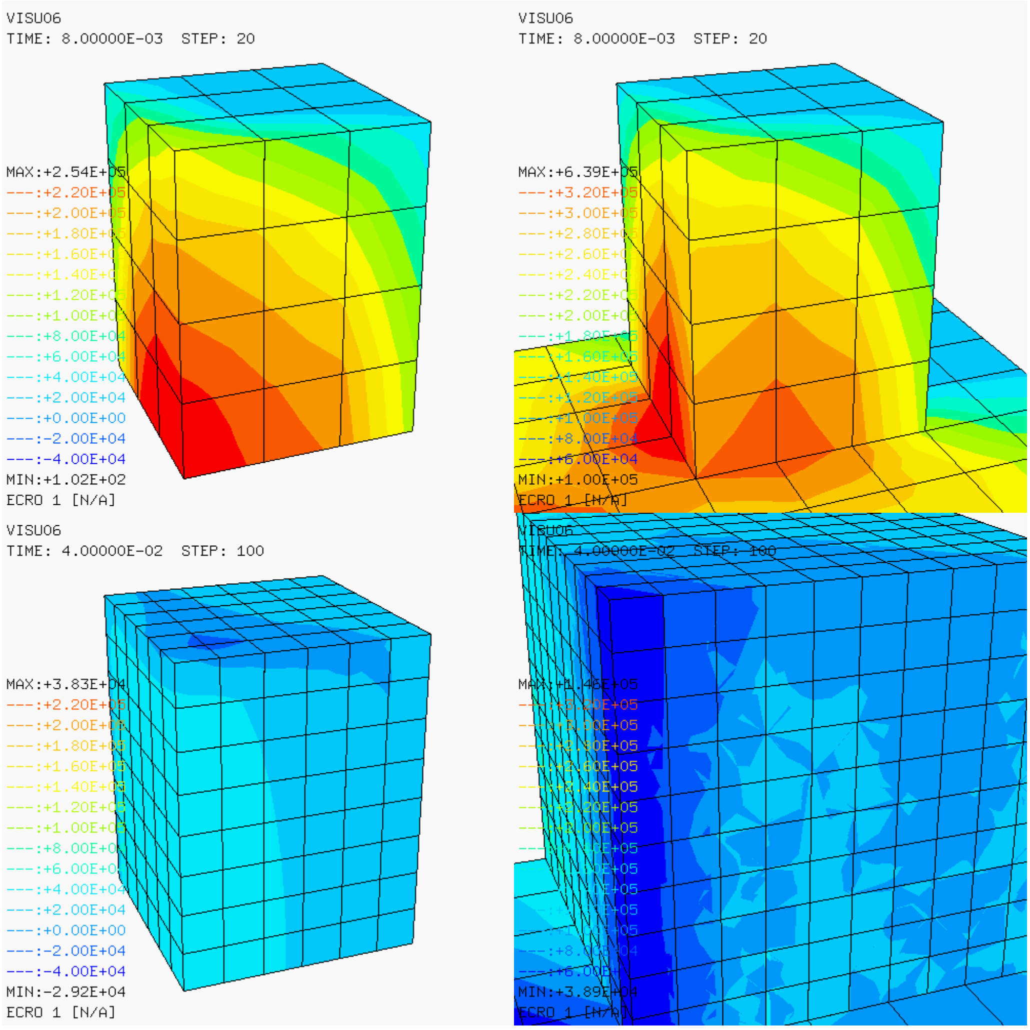
From the right part of Figure 12 we see, on one hand, that the "standard" visualization of FSI pressures (using the back faces of the fluid domain) does not work as expected in this case. In fact, because of adaptivity, what we see here are the back faces at the interface between the coarser and the finer fluid mesh, and not on the surface of the imaginary building (which looks "fatter" in this case).

On the other hand, we see (left part of the picture) that the IMPE VISU technique works well in this case. When the fluid elements are refined at the initial time by means of the INIT ADAP directive, the attached CL3Q elements with the IMPE VISU material are automatically refined as well (and the same happens also to some of the CL3D elements along the non-absorbing boundary). Consequently, the FSI pressure maps obtained are twice finer than in the previous case and more details may be observed.

VISU06

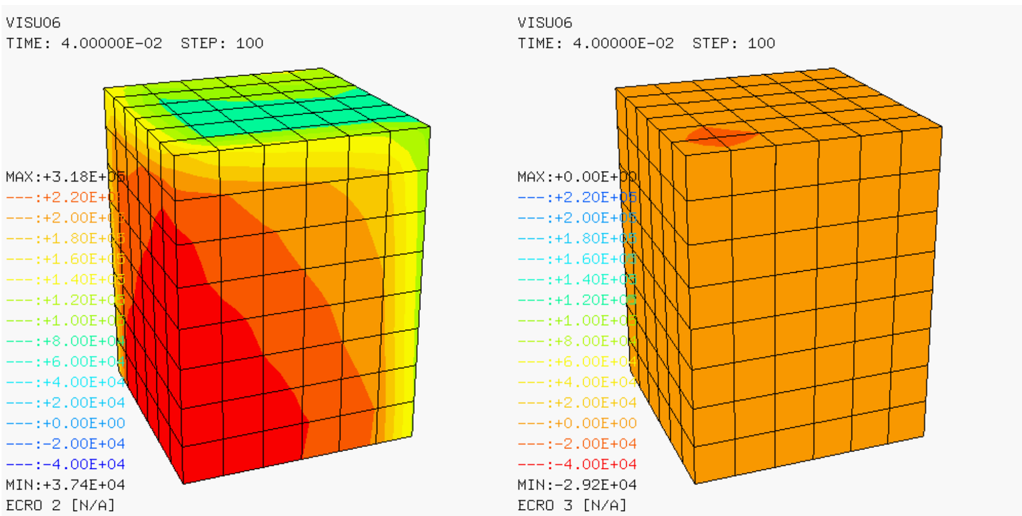
Th next simulation is similar to the previous one but the mesh is adaptively refined at a certain time (after 20 time steps of the calculation) and not at the beginning of the calculation. This test is more severe and representative of a real adaptive simulation because the mesh varies during the transient. For the sake of comparison, the time increment in these calculation is kept fixed and is equal in cases 03, 05 and 06.

Results of this calculation are shown in Figures 14 and 15 and confirm the observations made previously. Small differences with respect to case 05 are to be expected because the mesh in the two simulations is different over the first 20 time steps.



Visualization via IMPE VISU Standard visualization

Figure 14 - Fluid pressures on the building in case VISU06



Maximum FSI overpressure Maximum FSI underpressure (inverted colors)

Figure 15 - Maximum and minimum FSI overpressure maps in case VISU06.

4.2 Simulations with fluid and (embedded) structure

We now consider simulations involving both a fluid and an embedded structure. In this case, the CLxx elements with associated material IMPE VISU must be attached to the surface of the structure. The simulations performed are summarized in Table 2.

Case	Type	Fluid	CLxx	Notes
VISU04	Embedded	CUVF/GAZP	CL3Q	Base calculation
VISU07	Embedded	CUVF/GAZP	CL3Q	FLSW ADAP LMAX 2
VISU09	Embedded	CUVF/GAZP	CL3Q	FLSW ADAP LMAX 3

Table 2 - Fluid-only simulations

VISU04

The geometry of this problem is similar to that of case VISU03 but now we take a regular fluid box and we immerse in it a (coarsely meshed) structure representing the building. Since the structure is supposed to be rigid, we block all degrees of freedoms of structural nodes. Consequently, the numerical stability of structural elements should not be considered in the estimation of the Courant limit step.

CL3Q elements with the IMPE VISU DECO material are attached to the structure in order to visualize the FSI overpressure.

Some results of this calculation are shown in Figure 16. In the top row we can see the FSI overpressure at 20 and 100 steps, while in the bottom row we see the maximum overpressure and the minimum overpressure over the transient at the end of the calculation.

VISU07

This calculation is similar to VISU04 but we adaptively refine the fluid mesh in the vicinity of the structure by adding ADAP LMAX 2 to the FLSW directive. The (fixed) time step used is the same as in the previous calculation.

Results from this calculation are shown in Figure 17.

VISU09

This calculation is similar to VISU07 but we refine even further the fluid mesh in the vicinity of the structure by adding ADAP LMAX 3 to the FLSW directive. The time step used is one half that used in the previous two calculations.

Results from this calculation are shown in Figure 18, which includes also a view of FSI force vectors (FDEC).

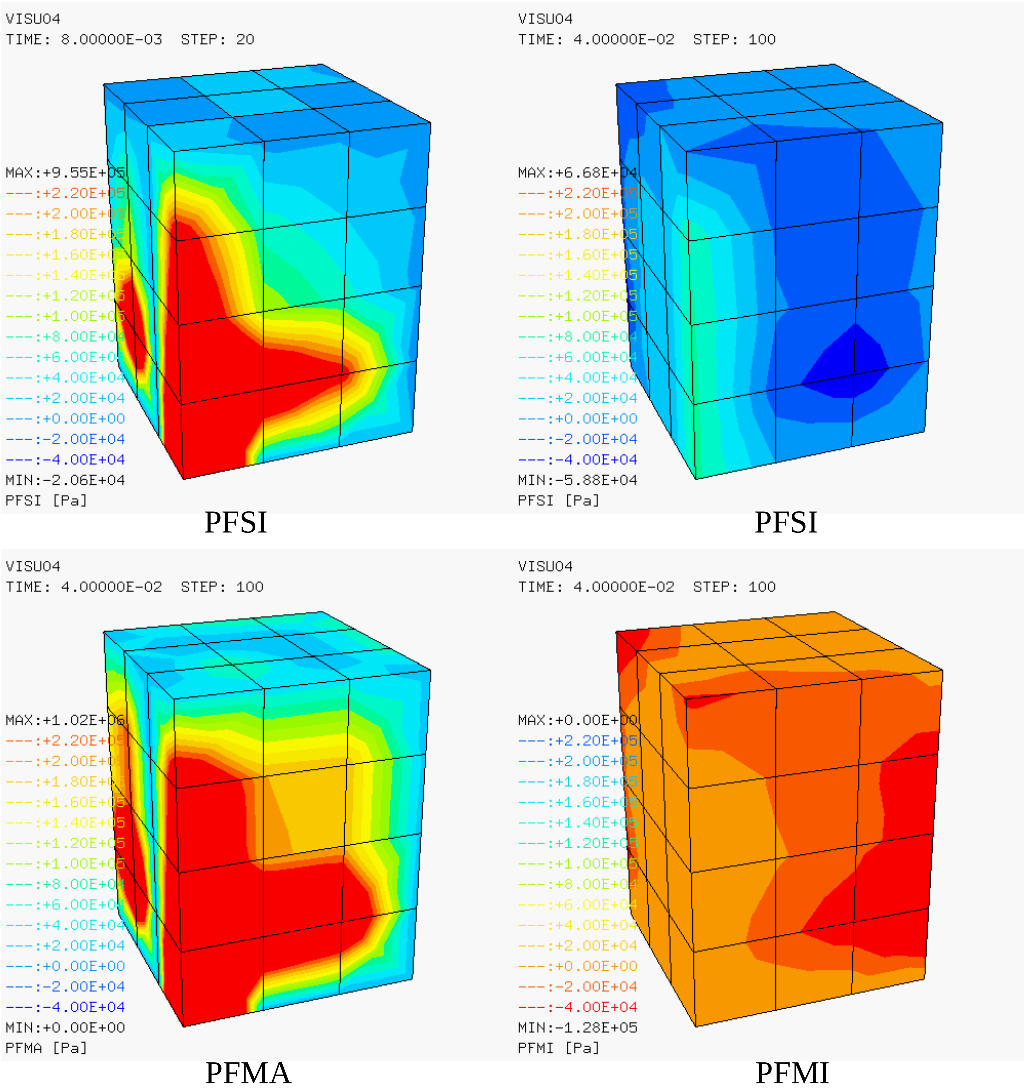


Figure 16 - Results in case VISU04

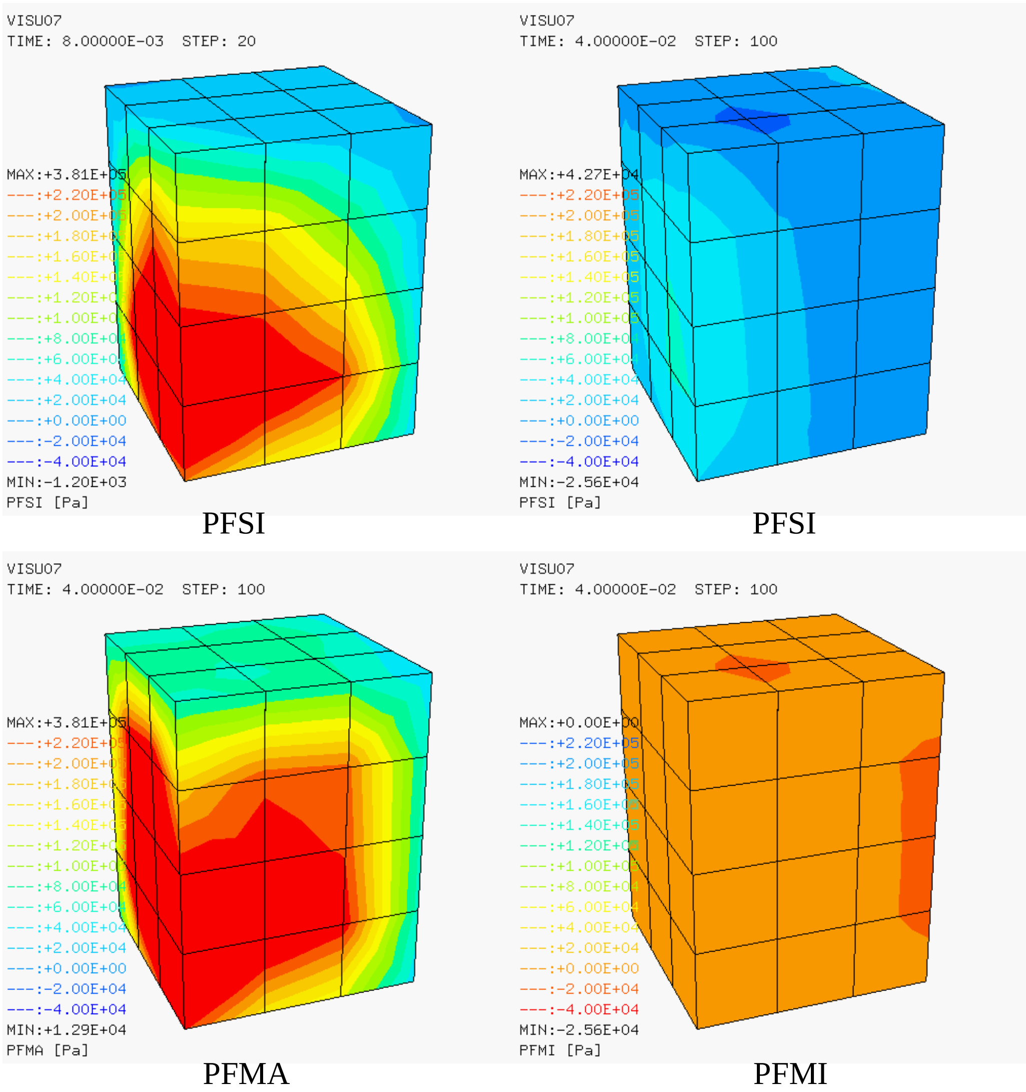


Figure 17 - Results in case VISU07

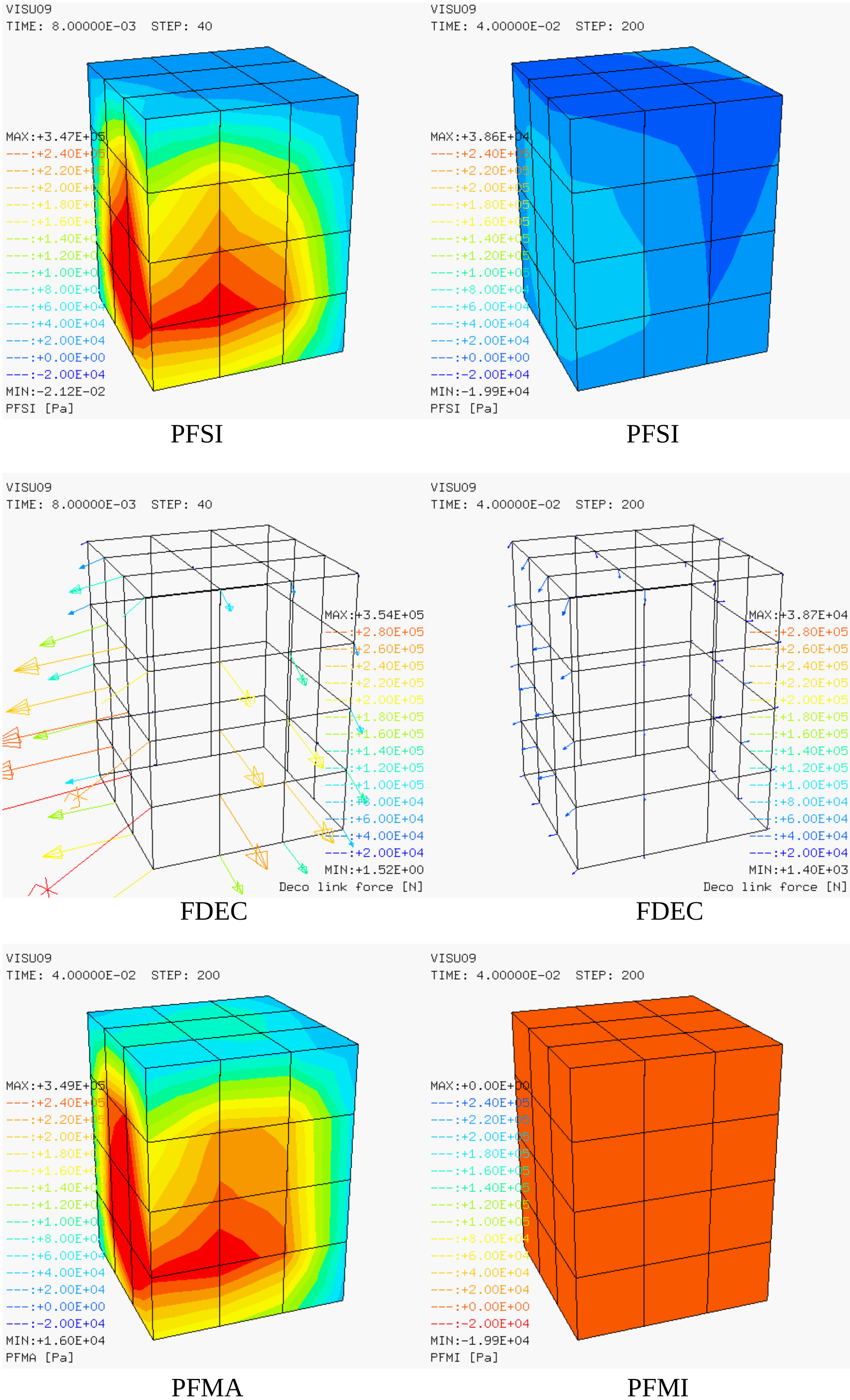


Figure 18 - Results in case VISU09

5. References

[1] "*EUROPLEXUS User's Manual*", on-line version: http://europlexus.jrc.ec.europa.eu.

[2] F. CASADEI, M. LARCHER, N. LECONTE: "*Strong and weak forms of a fully non-conforming FSI algorithm in fast transient dynamics for blast loading of structures*". PUBSY No. JRC60824. COMPDYN 2011, III ECCOMAS Thematic Conference on Computational Methods in Structural Dynamics and Earthquake Engineering, Corfu, Greece, May 25-28, 2011.

6. Appendix

Sample input files

This Section contains, in alphabetical file order, the listings of all input files related to the examples which were proposed in the previous Sections.

visu01.epx

```
VISU01
ECHO
 CONV WIN
ALE DPLA
DIME NALE 1 NBLE 1 TERM
GEOM LIBR POIN 33 Q4VF 20 ED01 2 CL22 2 TERM
  0 0  1 0  2 0  3 0  4 0  5 0
  0 1  1 1  2 1  3 1  4 1  5 1
  0 2  1 2  2 2  3 2  4 2  5 2
  0 3  1 3  2 3  3 3  4 3  5 3
  0 4  1 4  2 4  3 4  4 4  5 4
  2.5 0
  2.5 1.25
  2.5 2.5
  1 2 8 7
  2 3 9 8
  3 4 10 9
  4 5 11 10
  5 6 12 11
  7 8 14 13
  8 9 15 14
  9 10 16 15
  10 11 17 16
  11 12 18 17
  13 14 20 19
  14 15 21 20
  15 16 22 21
  16 17 23 22
  17 18 24 23
  19 20 26 25
  20 21 27 26
  21 22 28 27
  22 23 29 28
  23 24 30 29
  31 32
  32 33
  31 32
  32 33
COMP GROU 5 'flui' LECT 1 PAS 1 20 TERM
            'stru' LECT 21 22 TERM
            'visu' LECT 23 24 TERM
            'expl' LECT 1 TERM
            'air'  LECT flui DIFF expl TERM
     NGRO 1 'bast' LECT 31 TERM
     EPAI 1.E-2 LECT stru TERM
     COUL ROUG LECT expl TERM
          TURQ LECT air  TERM
          VERT LECT stru TERM
          JAUN LECT visu TERM
GRIL LAGR LECT stru TERM
     EULE LECT flui TERM
MATE VM23 RO 8000. YOUN 1.D11 NU 0.3 ELAS 2.D8
          TRAC 3 2.D8 2.D-3 3.D8 1. 3.1D8 2.
          LECT stru TERM
     GAZP RO 21 GAMMA 1.4 PINI 21E5 PREF 1E5
          LECT expl TERM
     GAZP RO 1 GAMMA 1.4 PINI 1E5 PREF 1E5
          LECT air TERM
     IMPE VISU DECO
          LECT visu TERM
LINK DECO
     BLOQ 123  LECT bast TERM
     FLSW STRU LECT stru TERM
          FLUI LECT flui TERM
          R    0.870 ! Radius of influence fluid-structure
                     ! >= 0.87 * dens fluid
          HGRI 1.500 ! Grid: slightly bigger than the biggest
                     ! structural element
          DGRI
          FACE
          BFLU 2 FSCP 1
ECRI FDEC ECRO VFCC FREQ 1
     FICH ALIC FREQ 1
OPTI PAS AUTO NOTE LOG 1
CALC TINI 0. TEND 0.1
FIN
```

visu02.epx

```
VISU02
ECHO
 CONV WIN
EULE DPLA
GEOM LIBR POIN 28 Q4VF 16 CL22 6 TERM
  0 0  1 0  2 0       4 0  5 0
  0 1  1 1  2 1       4 1  5 1
  0 2  1 2  2 2  3 2  4 2  5 2
  0 3  1 3  2 3  3 3  4 3  5 3
  0 4  1 4  2 4  3 4  4 4  5 4
  1 2 7 6
  2 3 8 7
  4 5 10 9
  6 7 12 11
  7 8 13 12
  9 10 16 15
  11 12 18 17
  12 13 19 18
  13 14 20 19
  14 15 21 20
  15 16 22 21
  17 18 24 23
  18 19 25 24
  19 20 26 25
  20 21 27 26
  21 22 28 27
  3 8
  8 13
  13 14
  14 15
  15 9
  9 4
COMP GROU 4 'flui' LECT 1 PAS 1 16 TERM
            'visu' LECT 17 PAS 1 22 TERM
            'expl' LECT 1 TERM
            'air'  LECT flui DIFF expl TERM
     COUL ROUG LECT expl TERM
          TURQ LECT air  TERM
          JAUN LECT visu TERM
MATE GAZP RO 21 GAMMA 1.4 PINI 21E5 PREF 1E5
          LECT expl TERM
     GAZP RO 1 GAMMA 1.4 PINI 1E5 PREF 1E5
          LECT air TERM
     IMPE VISU
          LECT visu TERM
ECRI FDEC ECRO VFCC FREQ 1
     FICH ALIC FREQ 1
OPTI PAS AUTO NOTE LOG 1
CALC TINI 0. TEND 0.1
FIN
```

visu03.dgibi

```
opti echo 1;
opti dime 3 elem cub8;
*
************************************************************************
'DEBPROC' pxbox3d x0*'FLOTTANT' y0*'FLOTTANT' z0*'FLOTTANT'
                  lx*'FLOTTANT' ly*'FLOTTANT' lz*'FLOTTANT'
                  dd*'FLOTTANT';
*
*-----------------------------------------------
* Generates a parallelepiped mesh with origin in point
* (x0,y0,z0), sides of length (lx,ly,lz) and density (mesh size) dd.
* The mesh consists of CUB8 hexahedral elements and is oriented
* along the global axes.
*
* Input :
* -----
*     x0,y0,z0 : coordinates of 'origin' of the box
*     lx,ly,lz : length of the box sides
*     dd : "density" (size) of the mesh (the same in all directions)
* Output :
* ------
*     box : mesh consisting of CUB8 hexahedra
*-----------------------------------------------
*
dens dd;
p1 = x0 y0 z0;
p2 = (x0 + lx) y0 z0;
p3 = (x0 + lx) (y0 + ly) z0;
p4 = x0 (y0 + ly) z0;
*
c1 = p1 d p2;
c2 = p2 d p3;
c3 = p3 d p4;
c4 = p4 d p1;
base = dall c1 c2 c3 c4 plan;
*
box = base volu tran (0 0 lz);
*
finproc box;
*
************************************************************************
'DEBPROC' pxsbox3d x0*'FLOTTANT' y0*'FLOTTANT' z0*'FLOTTANT'
                   lx*'FLOTTANT' ly*'FLOTTANT' lz*'FLOTTANT'
                   dd*'FLOTTANT';
*
*-----------------------------------------------
* Generates a structure box mesh with origin in point
* (x0,y0,z0), sides of length (lx,ly,lz) and density (mesh size) dd.
* The mesh consists of QUA4 quadrilateral elements and is oriented
* along the global axes.
* The box has solid "walls" and a solid "roof" but an empty "base",
* thus resembling a sort of building.
*
* Input :
* -----
*     x0,y0,z0 : coordinates of 'origin' of the box
*     lx,ly,lz : length of the box sides
*     dd : "density" (size) of the mesh (the same in all directions)
* Output :
* ------
*     box : mesh consisting of QUA4 quadrilaterals
*-----------------------------------------------
*
dens dd;
p1 = x0 y0 z0;
p2 = (x0 + lx) y0 z0;
p3 = (x0 + lx) (y0 + ly) z0;
p4 = x0 (y0 + ly) z0;
*
c1 = p1 d p2;
c2 = p2 d p3;
c3 = p3 d p4;
c4 = p4 d p1;
roof = (dall c1 c2 c3 c4 plan) plus (0 0 lz);
*
peri = c1 et c2 et c3 et c4;
slat = tran peri (0 0 lz);
*
box = slat et roof;
```

```
tol = dd * 0.01;
elim tol box;
*
finproc box;
**********************************************************************
*
opti trac psc ftra 'visu03_mesh.ps';
opti sauv form 'visu03.msh';
*
* Mesh size
*
den = 1.0;
tol = 0.01;
*
* Atmosphere
atmo = pxbox3d   0   0   0   8   6   6 den;
list (nbel atmo);
*
* Building
buil = pxbox3d   3   2   0   3   3   4 den;
*
elim tol (atmo et buil);
*
flui = diff atmo buil;
*list (nbel flui);
*
trac cach qual flui;
lines = aret flui;
trac qual lines;
*
* Absorbing boundary
*
ba = bary atmo;
*
abstop = (face 2 atmo) orie poin ba;
surlat = (face 3 atmo) orie poin ba;
abslat = (surlat elem appu stri flui) orie poin ba;
trac cach qual abstop;
trac cach qual abslat;
abso = abstop et abslat;
trac cach qual abso;
*
visu = pxsbox3d   3   2   0   3   3   4 den;
elim tol (flui et visu);
trac cach qual visu;
*
mesh = flui et abso et visu;
tass mesh noop;
sauv form mesh;
*
fin;
```

visu03.epx

```
VISU03
ECHO
 CONV WIN
CAST mesh
TRID EULE
GEOM CUVF flui
     CL3D abso
     CL3Q visu TERM
COMP GROU 2 'expl' LECT flui TERM COND NEAR POIN 0 0 0
            'air'  LECT flui DIFF expl TERM
     COUL ROUG LECT expl TERM
          TURQ LECT air  TERM
          JAUN LECT abso TERM
          VERT LECT visu TERM
MATE GAZP RO 100 GAMMA 1.4 PINI 100E5 PREF 1E5
          LECT expl TERM
     GAZP RO 1 GAMMA 1.4 PINI 1E5 PREF 1E5
          LECT air  TERM
     CLVF ABSO RO 1 LECT abso TERM
     IMPE VISU
          LECT visu TERM
ECRI ECRO VFCC FREQ 20
     FICH ALIC FREQ 1
OPTI NOTE LOG 1
     PAS UTIL
     VFCC NTIL
CALC TINI 0.0 TFIN 40.E-3 PASF 0.4E-3 NMAX 100
*=====================================================================
PLAY
CAME   1 EYE  -2.76637E-01 -9.06588E+00  7.63759E+00
!        Q     8.19005E-01  5.44625E-01 -1.00078E-01 -1.50329E-01
         VIEW  3.27675E-01  8.62012E-01 -3.86736E-01
         RIGH  9.34771E-01 -3.55251E-01  1.82185E-04
         UP    1.37231E-01  3.61569E-01  9.22191E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  4.50000E+00  3.50000E+00  2.00000E+00
!RSPHERE:  2.91548E+00
!RADIUS :  1.45774E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.13704E+01
!FAR    :  2.04083E+01
SCEN GEOM NAVI FREE
     ISO  FILL FIEL ECRO 1 SCAL USER PROG -0.4E5 PAS 0.2E5 2.2E5 TERM
          SUPP LECT visu TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 10 KFRE 10 COMP -1
     OBJE LECT visu TERM REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL
     OBJE LECT visu TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT visu TERM REND
ENDPLAY
*=====================================================================
SUIT
Post-treatment
RESU ALIC GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE  -2.76637E-01 -9.06588E+00  7.63759E+00
!        Q     8.19005E-01  5.44625E-01 -1.00078E-01 -1.50329E-01
         VIEW  3.27675E-01  8.62012E-01 -3.86736E-01
         RIGH  9.34771E-01 -3.55251E-01  1.82185E-04
         UP    1.37231E-01  3.61569E-01  9.22191E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  4.50000E+00  3.50000E+00  2.00000E+00
!RSPHERE:  2.91548E+00
!RADIUS :  1.45774E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.13704E+01
!FAR    :  2.04083E+01
SCEN GEOM NAVI FREE
          FACE SBAC
     ISO  FILL FIEL ECRO 1 SCAL USER PROG 0.6E5 PAS 0.2E5 3.2E5 TERM
          SUPP LECT flui TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 10 KFRE 10 COMP -1
     OBJE LECT flui abso TERM REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL
     OBJE LECT flui abso TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT flui abso TERM REND
ENDPLAY
*=====================================================================
SUIT
Post-treatment
RESU ALIC GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE  -2.76637E-01 -9.06588E+00  7.63759E+00
!        Q     8.19005E-01  5.44625E-01 -1.00078E-01 -1.50329E-01
         VIEW  3.27675E-01  8.62012E-01 -3.86736E-01
         RIGH  9.34771E-01 -3.55251E-01  1.82185E-04
         UP    1.37231E-01  3.61569E-01  9.22191E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  4.50000E+00  3.50000E+00  2.00000E+00
!RSPHERE:  2.91548E+00
!RADIUS :  1.45774E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.13704E+01
!FAR    :  2.04083E+01
SCEN GEOM NAVI FREE
     ISO  FILL FIEL ECRO 2 SCAL USER PROG -0.4E5 PAS 0.2E5 2.2E5 TERM
          SUPP LECT visu TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 10 KFRE 10 COMP -1
     OBJE LECT visu TERM REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL
     OBJE LECT visu TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT visu TERM REND
ENDPLAY
*=====================================================================
SUIT
Post-treatment
RESU ALIC GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE  -2.76637E-01 -9.06588E+00  7.63759E+00
!        Q     8.19005E-01  5.44625E-01 -1.00078E-01 -1.50329E-01
         VIEW  3.27675E-01  8.62012E-01 -3.86736E-01
         RIGH  9.34771E-01 -3.55251E-01  1.82185E-04
         UP    1.37231E-01  3.61569E-01  9.22191E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  4.50000E+00  3.50000E+00  2.00000E+00
!RSPHERE:  2.91548E+00
!RADIUS :  1.45774E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.13704E+01
!FAR    :  2.04083E+01
SCEN GEOM NAVI FREE
     ISO  FILL FIEL ECRO 3 SCAL USER PROG -0.4E5 PAS 0.2E5 2.2E5 TERM
          SUPP LECT visu TERM
          COSC ICOL ! Invert colors scale
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 10 KFRE 10 COMP -1
     OBJE LECT visu TERM REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL
     OBJE LECT visu TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT visu TERM REND
ENDPLAY
*=====================================================================
FIN
```

visu03a.epx

```
VISU03A
ECHO
RESU ALIC 'visu03.ali' GARD PSCR
OPTI PRIN
SORT GRAP
AXTE 1.0 'Time [s]'
```

```
COUR  1 'e2_469' ECRO COMP 2 ELEM LECT 469 TERM
COUR  2 'e2_480' ECRO COMP 2 ELEM LECT 480 TERM
COUR  3 'e2_481' ECRO COMP 2 ELEM LECT 481 TERM
COUR  4 'e2_492' ECRO COMP 2 ELEM LECT 492 TERM
COUR  5 'e2_525' ECRO COMP 2 ELEM LECT 525 TERM
COUR  6 'e3_469' ECRO COMP 3 ELEM LECT 469 TERM
COUR  7 'e3_480' ECRO COMP 3 ELEM LECT 480 TERM
COUR  8 'e3_481' ECRO COMP 3 ELEM LECT 481 TERM
COUR  9 'e3_492' ECRO COMP 3 ELEM LECT 492 TERM
COUR 10 'e3_525' ECRO COMP 3 ELEM LECT 525 TERM
COUR 11 'e1_469' ECRO COMP 1 ELEM LECT 469 TERM
COUR 12 'e1_480' ECRO COMP 1 ELEM LECT 480 TERM
COUR 13 'e1_481' ECRO COMP 1 ELEM LECT 481 TERM
COUR 14 'e1_492' ECRO COMP 1 ELEM LECT 492 TERM
COUR 15 'e1_525' ECRO COMP 1 ELEM LECT 525 TERM
TRAC 1  2 3 4 5 6 7 8 9 10 AXES 1.0 'PRESS. [PA]'
TRAC 1  6 11 AXES 1.0 'PRESS. [PA]'
TRAC 2  7 12 AXES 1.0 'PRESS. [PA]'
TRAC 3  8 13 AXES 1.0 'PRESS. [PA]'
TRAC 4  9 14 AXES 1.0 'PRESS. [PA]'
TRAC 5 10 15 AXES 1.0 'PRESS. [PA]'
FIN
```

visu04.dgibi

```
opti echo 1;
opti dime 3 elem cub8;
*
*************************************************************************
'DEBPROC' pxbox3d x0*'FLOTTANT' y0*'FLOTTANT' z0*'FLOTTANT'
                  lx*'FLOTTANT' ly*'FLOTTANT' lz*'FLOTTANT'
                  dd*'FLOTTANT';
*
*-------------------------------------------------
* Generates a parallelepiped mesh with origin in point
* (x0,y0,z0), sides of length (lx,ly,lz) and density (mesh size) dd.
* The mesh consists of CUB8 hexahedral elements and is oriented
* along the global axes.
*
* Input :
* -----
*     x0,y0,z0 : coordinates of 'origin' of the box
*     lx,ly,lz : length of the box sides
*     dd : "density" (size) of the mesh (the same in all directions)
* Output :
* ------
*     box : mesh consisting of CUB8 hexahedra
*-------------------------------------------------
*
dens dd;
p1 = x0 y0 z0;
p2 = (x0 + lx) y0 z0;
p3 = (x0 + lx) (y0 + ly) z0;
p4 = x0 (y0 + ly) z0;
*
c1 = p1 d p2;
c2 = p2 d p3;
c3 = p3 d p4;
c4 = p4 d p1;
base = dall c1 c2 c3 c4 plan;
*
box = base volu tran (0 0 lz);
*
finproc box;
*
*************************************************************************
'DEBPROC' pxsbox3d x0*'FLOTTANT' y0*'FLOTTANT' z0*'FLOTTANT'
                   lx*'FLOTTANT' ly*'FLOTTANT' lz*'FLOTTANT'
                   dd*'FLOTTANT';
*
*-------------------------------------------------
* Generates a structure box mesh with origin in point
* (x0,y0,z0), sides of length (lx,ly,lz) and density (mesh size) dd.
* The mesh consists of QUA4 quadrilateral elements and is oriented
* along the global axes.
* The box has solid "walls" and a solid "roof" but an empty "base",
* thus resembling a sort of building.
*
* Input :
* -----
*     x0,y0,z0 : coordinates of 'origin' of the box
*     lx,ly,lz : length of the box sides
*     dd : "density" (size) of the mesh (the same in all directions)
* Output :
* ------
*     box : mesh consisting of QUA4 quadrilaterals
*-------------------------------------------------
*
dens dd;
p1 = x0 y0 z0;
p2 = (x0 + lx) y0 z0;
p3 = (x0 + lx) (y0 + ly) z0;
p4 = x0 (y0 + ly) z0;
*
c1 = p1 d p2;
c2 = p2 d p3;
c3 = p3 d p4;
c4 = p4 d p1;
roof = (dall c1 c2 c3 c4 plan) plus (0 0 lz);
*
peri = c1 et c2 et c3 et c4;
slat = tran peri (0 0 lz);
*
box = slat et roof;
tol = dd * 0.01;
elim tol box;
*
finproc box;
*************************************************************************
*
opti trac psc ftra 'visu04_mesh.ps';
opti sauv form 'visu04.msh';
*
* Mesh size
*
den = 1.0;
tol = 0.01;
*
* Atmosphere
flui = pxbox3d   0   0   0   8   6   6 den;
list (nbel flui);
*
* Building
buil = pxsbox3d   3   2   0   3   3   4 den;
*
*list (nbel flui);
*
trac cach qual flui;
lines = aret flui;
trac qual lines;
*
* Absorbing boundary
*
ba = bary flui;
*
abstop = (face 2 flui) orie poin ba;
abslat = (face 3 flui) orie poin ba;
trac cach qual abstop;
trac cach qual abslat;
abso = abstop et abslat;
trac cach qual abso;
*
visu = (buil coul vert) orie poin (bary buil);
trac cach qual visu;
*
mesh = flui et buil et abso et visu;
tass mesh noop;
sauv form mesh;
*
fin;
```

visu04.epx

```
VISU04
ECHO
!CONV WIN
CAST mesh
TRID ALE
DIME NALE 1 NBLE 1 TERM
GEOM CUVF flui
     Q4GS buil
     CL3D abso
     CL3Q visu TERM
COMP EPAI 0.1 LECT buil TERM
     GROU 2 'expl' LECT flui TERM COND NEAR POIN 0 0 0
            'air'  LECT flui DIFF expl TERM
     COUL ROUG LECT expl TERM
          TURQ LECT air  TERM
          ROSE LECT buil TERM
          JAUN LECT abso TERM
          VERT LECT visu TERM
GRIL LAGR LECT buil TERM
     EULE LECT flui TERM
MATE GAZP RO 100 GAMMA 1.4 PINI 100E5 PREF 1E5
          LECT expl TERM
     GAZP RO 1 GAMMA 1.4 PINI 1E5 PREF 1E5
          LECT air  TERM
     VM23 RO 7800. YOUNG 1.6E11 NU 0.333 ELAS 1.05E8
          TRAC 2 1.05E8 .656256E-3 1.6105E10 1.00066
          LECT buil TERM
     CLVF ABSO RO 1 LECT abso TERM
     IMPE VISU DECO
          LECT visu TERM
LINK COUP SPLT NONE
          BLOQ 123456 LECT buil TERM
LINK DECO FLSW STRU LECT buil TERM
               FLUI LECT flui TERM
               R    0.870 ! Radius of influence fluid-structure
                          ! >= 0.87 * dens fluid
               HGRI 1.500 ! Grid: slightly bigger than the biggest
                          ! structural element
               DGRI
               FACE
               BFLU 2 FSCP 1
ECRI ECRO VFCC FREQ 20
     FICH ALIC FREQ 1
OPTI NOTE LOG 1
     PAS UTIL
     NOCR LECT buil TERM
     VFCC NTIL
CALC TINI 0.0 TFIN 40.E-3 PASF 0.4E-3 NMAX 100
*=================================================================
PLAY
CAME   1 EYE  -2.76637E-01 -9.06588E+00  7.63759E+00
!        Q     8.19005E-01  5.44625E-01 -1.00078E-01 -1.50329E-01
         VIEW  3.27675E-01  8.62012E-01 -3.86736E-01
         RIGH  9.34771E-01 -3.55251E-01  1.82185E-04
         UP    1.37231E-01  3.61569E-01  9.22191E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  4.50000E+00  3.50000E+00  2.00000E+00
!RSPHERE:  2.91548E+00
!RADIUS :  1.45774E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.13704E+01
!FAR    :  2.04083E+01
SCEN GEOM NAVI FREE
          FACE SBAC
     ISO  FILL FIEL PFSI SCAL USER PROG -0.4E5 PAS 0.2E5 2.2E5 TERM
          SUPP LECT visu TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 10 KFRE 10 COMP -1
     OBJE LECT visu TERM REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL
     OBJE LECT visu TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT visu TERM REND
ENDPLAY
```

```
*=====================================================================
SUIT
Post-treatment
RESU ALIC GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE  -2.76637E-01 -9.06588E+00  7.63759E+00
!        Q     8.19005E-01  5.44625E-01 -1.00078E-01 -1.50329E-01
         VIEW  3.27675E-01  8.62012E-01 -3.86736E-01
         RIGH  9.34771E-01 -3.55251E-01  1.82185E-04
         UP    1.37231E-01  3.61569E-01  9.22191E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  4.50000E+00  3.50000E+00  2.00000E+00
!RSPHERE:  2.91548E+00
!RADIUS :  1.45774E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.13704E+01
!FAR    :  2.04083E+01
SCEN GEOM NAVI FREE
          FACE SBAC
     ISO  FILL FIEL PFMA SCAL USER PROG -0.4E5 PAS 0.2E5 2.2E5 TERM
          SUPP LECT visu TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 10 KFRE 10 COMP -1
     OBJE LECT visu TERM REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL
     OBJE LECT visu TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT visu TERM REND
ENDPLAY
*=====================================================================
SUIT
Post-treatment
RESU ALIC GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE  -2.76637E-01 -9.06588E+00  7.63759E+00
!        Q     8.19005E-01  5.44625E-01 -1.00078E-01 -1.50329E-01
         VIEW  3.27675E-01  8.62012E-01 -3.86736E-01
         RIGH  9.34771E-01 -3.55251E-01  1.82185E-04
         UP    1.37231E-01  3.61569E-01  9.22191E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  4.50000E+00  3.50000E+00  2.00000E+00
!RSPHERE:  2.91548E+00
!RADIUS :  1.45774E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.13704E+01
!FAR    :  2.04083E+01
SCEN GEOM NAVI FREE
          FACE SBAC
     ISO  FILL FIEL PFMI SCAL USER PROG -0.4E5 PAS 0.2E5 2.2E5 TERM
          SUPP LECT visu TERM
          COSC ICOL ! Invert colors scale
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 10 KFRE 10 COMP -1
     OBJE LECT visu TERM REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL
     OBJE LECT visu TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT visu TERM REND
ENDPLAY
*=====================================================================
FIN
```

visu05.dgibi

```
opti echo 1;
opti dime 3 elem cub8;
*
*************************************************************************
'DEBPROC' pxbox3d x0*'FLOTTANT' y0*'FLOTTANT' z0*'FLOTTANT'
                  lx*'FLOTTANT' ly*'FLOTTANT' lz*'FLOTTANT'
                  dd*'FLOTTANT';
*
*-------------------------------------------------
* Generates a parallelepiped mesh with origin in point
* (x0,y0,z0), sides of length (lx,ly,lz) and density (mesh size) dd.
* The mesh consists of CUB8 hexahedral elements and is oriented
* along the global axes.
*
* Input :
* -----
*     x0,y0,z0 : coordinates of 'origin' of the box
*     lx,ly,lz : length of the box sides
*     dd : "density" (size) of the mesh (the same in all directions)
* Output :
* ------
*     box : mesh consisting of CUB8 hexahedra
*-------------------------------------------------
*
dens dd;
p1 = x0 y0 z0;
p2 = (x0 + lx) y0 z0;
p3 = (x0 + lx) (y0 + ly) z0;
p4 = x0 (y0 + ly) z0;
*
c1 = p1 d p2;
c2 = p2 d p3;
c3 = p3 d p4;
c4 = p4 d p1;
base = dall c1 c2 c3 c4 plan;
*
box = base volu tran (0 0 lz);
*
finproc box;
*
*************************************************************************
'DEBPROC' pxsbox3d x0*'FLOTTANT' y0*'FLOTTANT' z0*'FLOTTANT'
                   lx*'FLOTTANT' ly*'FLOTTANT' lz*'FLOTTANT'
                   dd*'FLOTTANT';
*
*-------------------------------------------------
* Generates a structure box mesh with origin in point
* (x0,y0,z0), sides of length (lx,ly,lz) and density (mesh size) dd.
* The mesh consists of QUA4 quadrilateral elements and is oriented
* along the global axes.
* The box has solid "walls" and a solid "roof" but an empty "base",
* thus resembling a sort of building.
*
* Input :
* -----
*     x0,y0,z0 : coordinates of 'origin' of the box
*     lx,ly,lz : length of the box sides
*     dd : "density" (size) of the mesh (the same in all directions)
* Output :
* ------
*     box : mesh consisting of QUA4 quadrilaterals
*-------------------------------------------------
*
dens dd;
p1 = x0 y0 z0;
p2 = (x0 + lx) y0 z0;
p3 = (x0 + lx) (y0 + ly) z0;
p4 = x0 (y0 + ly) z0;
*
c1 = p1 d p2;
c2 = p2 d p3;
c3 = p3 d p4;
c4 = p4 d p1;
roof = (dall c1 c2 c3 c4 plan) plus (0 0 lz);
*
peri = c1 et c2 et c3 et c4;
slat = tran peri (0 0 lz);
*
box = slat et roof;
tol = dd * 0.01;
elim tol box;
*
finproc box;
*************************************************************************
*
opti trac psc ftra 'visu05_mesh.ps';
opti sauv form 'visu05.msh';
*
* Mesh size
*
den = 1.0;
tol = 0.01;
*
* Atmosphere
atmo = pxbox3d   0   0   0   8   6   6 den;
list (nbel atmo);
*
* Building
buil = pxbox3d   3   2   0   3   3   4 den;
*
elim tol (atmo et buil);
*
flui = diff atmo buil;
*list (nbel flui);
*
trac cach qual flui;
lines = aret flui;
trac qual lines;
*
* Absorbing boundary
*
ba = bary atmo;
*
abstop = (face 2 atmo) orie poin ba;
surlat = (face 3 atmo) orie poin ba;
abslat = (surlat elem appu stri flui) orie poin ba;
trac cach qual abstop;
trac cach qual abslat;
abso = abstop et abslat;
trac cach qual abso;
*
visu = pxsbox3d   3   2   0   3   3   4 den;
elim tol (flui et visu);
trac cach qual visu;
adap = flui elem appu larg visu;
trac cach qual adap;
*
mesh = flui et abso et visu;
tass mesh noop;
sauv form mesh;
*
fin;
```

visu05.epx

```
VISU05
ECHO
 CONV WIN
CAST mesh
TRID EULE
DIME ADAP NPOI 931 CUVF 712 CL3Q 228 CL3D 100 NVFI 2532 ENDA TERM
GEOM CUVF flui
     CL3D abso
     CL3Q visu TERM
COMP GROU 2 'expl' LECT flui TERM COND NEAR POIN 0 0 0
            'air'  LECT flui DIFF expl TERM
     COUL ROUG LECT expl TERM
          TURQ LECT air  TERM
          JAUN LECT abso TERM
          VERT LECT visu TERM
MATE GAZP RO 100 GAMMA 1.4 PINI 100E5 PREF 1E5
          LECT expl TERM
```

```
     GAZP RO 1 GAMMA 1.4 PINI 1E5 PREF 1E5
          LECT air  _cuvf TERM
     CLVF ABSO RO 1 LECT abso _cl3d TERM
     IMPE VISU
          LECT visu _cl3q TERM
INIT ADAP SPLI LEVE 2 LECT adap TERM
ECRI ECRO VFCC FREQ 20
     FICH ALIC FREQ 1
OPTI NOTE LOG 1
     PAS UTIL
     VFCC NTIL
CALC TINI 0.0 TFIN 40.E-3 PASF 0.4E-3 NMAX 100
*=======================================================================
PLAY
CAME   1 EYE  -2.76637E-01 -9.06588E+00  7.63759E+00
!        Q      8.19005E-01  5.44625E-01 -1.00078E-01 -1.50329E-01
         VIEW  3.27675E-01  8.62012E-01 -3.86736E-01
         RIGH  9.34771E-01 -3.55251E-01  1.82185E-04
         UP     1.37231E-01  3.61569E-01  9.22191E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  4.50000E+00  3.50000E+00  2.00000E+00
!RSPHERE:  2.91548E+00
!RADIUS :  1.45774E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.13704E+01
!FAR    :  2.04083E+01
SCEN GEOM NAVI FREE
     ISO  FILL FIEL ECRO 1 SCAL USER PROG -0.4E5 PAS 0.2E5 2.2E5 TERM
          SUPP LECT visu TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 10 KFRE 10 COMP -1
     OBJE LECT visu TERM REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL
     OBJE LECT visu TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT visu TERM REND
ENDPLAY
*=======================================================================
SUIT
Post-treatment
RESU ALIC GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=======================================================================
PLAY
CAME   1 EYE  -2.76637E-01 -9.06588E+00  7.63759E+00
!        Q      8.19005E-01  5.44625E-01 -1.00078E-01 -1.50329E-01
         VIEW  3.27675E-01  8.62012E-01 -3.86736E-01
         RIGH  9.34771E-01 -3.55251E-01  1.82185E-04
         UP     1.37231E-01  3.61569E-01  9.22191E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  4.50000E+00  3.50000E+00  2.00000E+00
!RSPHERE:  2.91548E+00
!RADIUS :  1.45774E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.13704E+01
!FAR    :  2.04083E+01
SCEN GEOM NAVI FREE
          FACE SBAC
     ISO  FILL FIEL ECRO 1 SCAL USER PROG 0.6E5 PAS 0.2E5 3.2E5 TERM
          SUPP LECT flui TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 10 KFRE 10 COMP -1
     OBJE LECT flui abso TERM REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL
     OBJE LECT flui abso TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT flui abso TERM REND
ENDPLAY
*=======================================================================
SUIT
Post-treatment
RESU ALIC GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=======================================================================
PLAY
CAME   1 EYE  -2.76637E-01 -9.06588E+00  7.63759E+00
!        Q      8.19005E-01  5.44625E-01 -1.00078E-01 -1.50329E-01
         VIEW  3.27675E-01  8.62012E-01 -3.86736E-01
         RIGH  9.34771E-01 -3.55251E-01  1.82185E-04
         UP     1.37231E-01  3.61569E-01  9.22191E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  4.50000E+00  3.50000E+00  2.00000E+00
!RSPHERE:  2.91548E+00
!RADIUS :  1.45774E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.13704E+01
!FAR    :  2.04083E+01
SCEN GEOM NAVI FREE
     ISO  FILL FIEL ECRO 2 SCAL USER PROG -0.4E5 PAS 0.2E5 2.2E5 TERM
          SUPP LECT visu TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 10 KFRE 10 COMP -1
     OBJE LECT visu TERM REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL
     OBJE LECT visu TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT visu TERM REND
ENDPLAY
*=======================================================================
SUIT
Post-treatment
RESU ALIC GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=======================================================================
PLAY
CAME   1 EYE  -2.76637E-01 -9.06588E+00  7.63759E+00
!        Q      8.19005E-01  5.44625E-01 -1.00078E-01 -1.50329E-01
         VIEW  3.27675E-01  8.62012E-01 -3.86736E-01
         RIGH  9.34771E-01 -3.55251E-01  1.82185E-04
         UP     1.37231E-01  3.61569E-01  9.22191E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  4.50000E+00  3.50000E+00  2.00000E+00
!RSPHERE:  2.91548E+00
!RADIUS :  1.45774E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.13704E+01
!FAR    :  2.04083E+01
SCEN GEOM NAVI FREE
     ISO  FILL FIEL ECRO 3 SCAL USER PROG -0.4E5 PAS 0.2E5 2.2E5 TERM
          SUPP LECT visu TERM
          COSC ICOL ! Invert colors scale
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 10 KFRE 10 COMP -1
     OBJE LECT visu TERM REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL
     OBJE LECT visu TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT visu TERM REND
ENDPLAY
*=======================================================================
FIN
```

visu06.dgibi

```
opti echo 1;
opti dime 3 elem cub8;
*
************************************************************************
'DEBPROC' pxbox3d x0*'FLOTTANT' y0*'FLOTTANT' z0*'FLOTTANT'
                  lx*'FLOTTANT' ly*'FLOTTANT' lz*'FLOTTANT'
                  dd*'FLOTTANT';
*
*-------------------------------------------------
* Generates a parallelepiped mesh with origin in point
* (x0,y0,z0), sides of length (lx,ly,lz) and density (mesh size) dd.
* The mesh consists of CUB8 hexahedral elements and is oriented
* along the global axes.
*
* Input :
* -----
*     x0,y0,z0 : coordinates of 'origin' of the box
*     lx,ly,lz : length of the box sides
*     dd : "density" (size) of the mesh (the same in all directions)
* Output :
* ------
*     box : mesh consisting of CUB8 hexahedra
*-------------------------------------------------
*
dens dd;
p1 = x0 y0 z0;
p2 = (x0 + lx) y0 z0;
p3 = (x0 + lx) (y0 + ly) z0;
p4 = x0 (y0 + ly) z0;
*
c1 = p1 d p2;
c2 = p2 d p3;
c3 = p3 d p4;
c4 = p4 d p1;
base = dall c1 c2 c3 c4 plan;
*
box = base volu tran (0 0 lz);
*
finproc box;
*
************************************************************************
'DEBPROC' pxsbox3d x0*'FLOTTANT' y0*'FLOTTANT' z0*'FLOTTANT'
                   lx*'FLOTTANT' ly*'FLOTTANT' lz*'FLOTTANT'
                   dd*'FLOTTANT';
*
*-------------------------------------------------
* Generates a structure box mesh with origin in point
* (x0,y0,z0), sides of length (lx,ly,lz) and density (mesh size) dd.
* The mesh consists of QUA4 quadrilateral elements and is oriented
* along the global axes.
* The box has solid "walls" and a solid "roof" but an empty "base",
* thus resembling a sort of building.
*
* Input :
* -----
*     x0,y0,z0 : coordinates of 'origin' of the box
*     lx,ly,lz : length of the box sides
*     dd : "density" (size) of the mesh (the same in all directions)
* Output :
* ------
*     box : mesh consisting of QUA4 quadrilaterals
*-------------------------------------------------
*
dens dd;
p1 = x0 y0 z0;
p2 = (x0 + lx) y0 z0;
p3 = (x0 + lx) (y0 + ly) z0;
p4 = x0 (y0 + ly) z0;
*
c1 = p1 d p2;
c2 = p2 d p3;
c3 = p3 d p4;
c4 = p4 d p1;
roof = (dall c1 c2 c3 c4 plan) plus (0 0 lz);
*
peri = c1 et c2 et c3 et c4;
slat = tran peri (0 0 lz);
```

```
*
box = slat et roof;
tol = dd * 0.01;
elim tol box;
*
finproc box;
**********************************************************************
*
opti trac psc ftra 'visu06_mesh.ps';
opti sauv form 'visu06.msh';
*
* Mesh size
*
den = 1.0;
tol = 0.01;
*
* Atmosphere
atmo = pxbox3d   0   0   0   8   6   6 den;
list (nbel atmo);
*
* Building
buil = pxbox3d   3   2   0   3   3   4 den;
*
elim tol (atmo et buil);
*
flui = diff atmo buil;
*list (nbel flui);
*
trac cach qual flui;
lines = aret flui;
trac qual lines;
*
* Absorbing boundary
*
ba = bary atmo;
*
abstop = (face 2 atmo) orie poin ba;
surlat = (face 3 atmo) orie poin ba;
abslat = (surlat elem appu stri flui) orie poin ba;
trac cach qual abstop;
trac cach qual abslat;
abso = abstop et abslat;
trac cach qual abso;
*
visu = pxsbox3d   3   2   0   3   3   4 den;
elim tol (flui et visu);
trac cach qual visu;
adap = flui elem appu larg visu;
trac cach qual adap;
*
mesh = flui et abso et visu;
tass mesh noop;
sauv form mesh;
*
fin;
```

visu06.epx

```
VISU06
ECHO
 CONV WIN
CAST mesh
TRID EULE
DIME ADAP NPOI 931 CUVF 712 CL3Q 228 CL3D 100 NVFI 2532 ENDA TERM
GEOM CUVF flui
     CL3D abso
     CL3Q visu TERM
COMP GROU 2 'expl' LECT flui TERM COND NEAR POIN 0 0 0
              'air'  LECT flui DIFF expl TERM
     COUL ROUG LECT expl TERM
          TURQ LECT air  TERM
          JAUN LECT abso TERM
          VERT LECT visu TERM
MATE GAZP RO 100 GAMMA 1.4 PINI 100E5 PREF 1E5
          LECT expl TERM
     GAZP RO 1 GAMMA 1.4 PINI 1E5 PREF 1E5
          LECT air  _cuvf TERM
     CLVF ABSO RO 1 LECT abso _cl3d TERM
     IMPE VISU
          LECT visu _cl3q TERM
ECRI ECRO VFCC FREQ 20
     FICH ALIC FREQ 1
OPTI NOTE LOG 1
     PAS UTIL
     VFCC NTIL
CALC TINI 0.0 TFIN 40.E-3 PASF 0.4E-3 NMAX 100
*======================================================================
PLAY
CAME   1 EYE  -2.76637E-01 -9.06588E+00  7.63759E+00
!        Q     8.19005E-01  5.44625E-01 -1.00078E-01 -1.50329E-01
         VIEW  3.27675E-01  8.62012E-01 -3.86736E-01
         RIGH  9.34771E-01 -3.55251E-01  1.82185E-04
         UP    1.37231E-01  3.61569E-01  9.22191E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  4.50000E+00  3.50000E+00  2.00000E+00
!RSPHERE:  2.91548E+00
!RADIUS :  1.45774E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.13704E+01
!FAR    :  2.04083E+01
SCEN GEOM NAVI FREE
     ISO  FILL FIEL ECRO 1 SCAL USER PROG -0.4E5 PAS 0.2E5 2.2E5 TERM
          SUPP LECT visu TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 10 KFRE 10 COMP -1
     OBJE LECT visu TERM REND
FREQ 1
GOTR LOOP 20 OFFS FICH AVI CONT NOCL
     OBJE LECT visu TERM REND
ADAP SPLI OBJE LECT adap TERM TERM
GOTR LOOP 79 OFFS FICH AVI CONT NOCL
     OBJE LECT visu TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT visu TERM REND
ENDPLAY
*======================================================================
SUIT
Post-treatment
RESU ALIC GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*======================================================================
PLAY
CAME   1 EYE  -2.76637E-01 -9.06588E+00  7.63759E+00
!        Q     8.19005E-01  5.44625E-01 -1.00078E-01 -1.50329E-01
         VIEW  3.27675E-01  8.62012E-01 -3.86736E-01
         RIGH  9.34771E-01 -3.55251E-01  1.82185E-04
         UP    1.37231E-01  3.61569E-01  9.22191E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  4.50000E+00  3.50000E+00  2.00000E+00
!RSPHERE:  2.91548E+00
!RADIUS :  1.45774E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.13704E+01
!FAR    :  2.04083E+01
SCEN GEOM NAVI FREE
          FACE SBAC
     ISO  FILL FIEL ECRO 1 SCAL USER PROG 0.6E5 PAS 0.2E5 3.2E5 TERM
          SUPP LECT flui TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 10 KFRE 10 COMP -1
     OBJE LECT flui abso TERM REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL
     OBJE LECT flui abso TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT flui abso TERM REND
ENDPLAY
*======================================================================
SUIT
Post-treatment
RESU ALIC GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*======================================================================
PLAY
CAME   1 EYE  -2.76637E-01 -9.06588E+00  7.63759E+00
!        Q     8.19005E-01  5.44625E-01 -1.00078E-01 -1.50329E-01
         VIEW  3.27675E-01  8.62012E-01 -3.86736E-01
         RIGH  9.34771E-01 -3.55251E-01  1.82185E-04
         UP    1.37231E-01  3.61569E-01  9.22191E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  4.50000E+00  3.50000E+00  2.00000E+00
!RSPHERE:  2.91548E+00
!RADIUS :  1.45774E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.13704E+01
!FAR    :  2.04083E+01
SCEN GEOM NAVI FREE
     ISO  FILL FIEL ECRO 2 SCAL USER PROG -0.4E5 PAS 0.2E5 2.2E5 TERM
          SUPP LECT visu TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 10 KFRE 10 COMP -1
     OBJE LECT visu TERM REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL
     OBJE LECT visu TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT visu TERM REND
ENDPLAY
*======================================================================
SUIT
Post-treatment
RESU ALIC GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*======================================================================
PLAY
CAME   1 EYE  -2.76637E-01 -9.06588E+00  7.63759E+00
!        Q     8.19005E-01  5.44625E-01 -1.00078E-01 -1.50329E-01
         VIEW  3.27675E-01  8.62012E-01 -3.86736E-01
         RIGH  9.34771E-01 -3.55251E-01  1.82185E-04
         UP    1.37231E-01  3.61569E-01  9.22191E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  4.50000E+00  3.50000E+00  2.00000E+00
!RSPHERE:  2.91548E+00
!RADIUS :  1.45774E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.13704E+01
!FAR    :  2.04083E+01
SCEN GEOM NAVI FREE
     ISO  FILL FIEL ECRO 3 SCAL USER PROG -0.4E5 PAS 0.2E5 2.2E5 TERM
          SUPP LECT visu TERM
          COSC ICOL ! Invert colors scale
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 10 KFRE 10 COMP -1
     OBJE LECT visu TERM REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL
     OBJE LECT visu TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT visu TERM REND
ENDPLAY
*======================================================================
FIN
```

visu07.dgibi

```
opti echo 1;
opti dime 3 elem cub8;
*
*************************************************************************
'DEBPROC' pxbox3d x0*'FLOTTANT' y0*'FLOTTANT' z0*'FLOTTANT'
                  lx*'FLOTTANT' ly*'FLOTTANT' lz*'FLOTTANT'
                  dd*'FLOTTANT';
*
*--------------------------------------------------
* Generates a parallelepiped mesh with origin in point
* (x0,y0,z0), sides of length (lx,ly,lz) and density (mesh size) dd.
* The mesh consists of CUB8 hexahedral elements and is oriented
* along the global axes.
*
* Input :
* -----
*     x0,y0,z0 : coordinates of 'origin' of the box
*     lx,ly,lz : length of the box sides
*     dd : "density" (size) of the mesh (the same in all directions)
* Output :
* ------
*     box : mesh consisting of CUB8 hexahedra
*--------------------------------------------------
*
dens dd;
p1 = x0 y0 z0;
p2 = (x0 + lx) y0 z0;
p3 = (x0 + lx) (y0 + ly) z0;
p4 = x0 (y0 + ly) z0;
*
c1 = p1 d p2;
c2 = p2 d p3;
c3 = p3 d p4;
c4 = p4 d p1;
base = dall c1 c2 c3 c4 plan;
*
box = base volu tran (0 0 lz);
*
finproc box;
*
*************************************************************************
'DEBPROC' pxsbox3d x0*'FLOTTANT' y0*'FLOTTANT' z0*'FLOTTANT'
                   lx*'FLOTTANT' ly*'FLOTTANT' lz*'FLOTTANT'
                   dd*'FLOTTANT';
*
*--------------------------------------------------
* Generates a structure box mesh with origin in point
* (x0,y0,z0), sides of length (lx,ly,lz) and density (mesh size) dd.
* The mesh consists of QUA4 quadrilateral elements and is oriented
* along the global axes.
* The box has solid "walls" and a solid "roof" but an empty "base",
* thus resembling a sort of building.
*
* Input :
* -----
*     x0,y0,z0 : coordinates of 'origin' of the box
*     lx,ly,lz : length of the box sides
*     dd : "density" (size) of the mesh (the same in all directions)
* Output :
* ------
*     box : mesh consisting of QUA4 quadrilaterals
*--------------------------------------------------
*
dens dd;
p1 = x0 y0 z0;
p2 = (x0 + lx) y0 z0;
p3 = (x0 + lx) (y0 + ly) z0;
p4 = x0 (y0 + ly) z0;
*
c1 = p1 d p2;
c2 = p2 d p3;
c3 = p3 d p4;
c4 = p4 d p1;
roof = (dall c1 c2 c3 c4 plan) plus (0 0 lz);
*
peri = c1 et c2 et c3 et c4;
slat = tran peri (0 0 lz);
*
box = slat et roof;
tol = dd * 0.01;
elim tol box;
*
finproc box;
*************************************************************************
*
opti trac psc ftra 'visu07_mesh.ps';
opti sauv form 'visu07.msh';
*
* Mesh size
*
den = 1.0;
tol = 0.01;
*
* Atmosphere
flui = pxbox3d   0   0   0   8   6   6 den;
list (nbel flui);
*
* Building
buil = pxsbox3d   3   2   0   3   3   4 den;
*
*list (nbel flui);
*
trac cach qual flui;
lines = aret flui;
trac qual lines;
*
* Absorbing boundary
*
ba = bary flui;
*
abstop = (face 2 flui) orie poin ba;
abslat = (face 3 flui) orie poin ba;
trac cach qual abstop;
trac cach qual abslat;
abso = abstop et abslat;
trac cach qual abso;
*
visu = (buil coul vert) orie poin (bary buil);
trac cach qual visu;
*
mesh = flui et buil et abso et visu;
tass mesh noop;
sauv form mesh;
*
fin;
```

visu07.epx

```
VISU07
ECHO
!CONV WIN
CAST mesh
TRID ALE
DIME ADAP NPOI 1109 CUVF 976 CL3D 100 NVFI 3252 ENDA
     NALE 1 NBLE 1 TERM
GEOM CUVF flui
     Q4GS buil
     CL3D abso
     CL3Q visu TERM
COMP EPAI 0.1 LECT buil TERM
     GROU 2 'expl' LECT flui TERM COND NEAR POIN 0 0 0
            'air'  LECT flui DIFF expl TERM
     COUL ROUG LECT expl TERM
          TURQ LECT air  TERM
          ROSE LECT buil TERM
          JAUN LECT abso TERM
          VERT LECT visu TERM
GRIL LAGR LECT buil TERM
     EULE LECT flui TERM
MATE GAZP RO 100 GAMMA 1.4 PINI 100E5 PREF 1E5
          LECT expl TERM
     GAZP RO 1 GAMMA 1.4 PINI 1E5 PREF 1E5
          LECT air _cuvf TERM
     VM23 RO 7800. YOUNG 1.6E11 NU 0.333 ELAS 1.05E8
          TRAC 2 1.05E8 .656256E-3 1.6105E10 1.00066
          LECT buil TERM
     CLVF ABSO RO 1 LECT abso _cl3d TERM
     IMPE VISU DECO
          LECT visu TERM
LINK COUP SPLT NONE
          BLOQ 123456 LECT buil TERM
LINK DECO FLSW STRU LECT buil TERM
               FLUI LECT flui TERM
               R    0.870 ! Radius of influence fluid-structure
                          ! >= 0.87 * dens fluid
               HGRI 1.500 ! Grid: slightly bigger than the biggest
                          ! structural element
               DGRI
               FACE
               BFLU 2 FSCP 1
               ADAP LMAX 2
ECRI ECRO VFCC FREQ 20
     FICH ALIC FREQ 1
OPTI NOTE LOG 1
     PAS UTIL
     NOCR LECT buil TERM
     VFCC NTIL
CALC TINI 0.0 TFIN 40.E-3 PASF 0.4E-3 NMAX 100
*=====================================================================
PLAY
CAME   1 EYE  -2.76637E-01 -9.06588E+00  7.63759E+00
!        Q     8.19005E-01  5.44625E-01 -1.00078E-01 -1.50329E-01
         VIEW  3.27675E-01  8.62012E-01 -3.86736E-01
         RIGH  9.34771E-01 -3.55251E-01  1.82185E-04
         UP    1.37231E-01  3.61569E-01  9.22191E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  4.50000E+00  3.50000E+00  2.00000E+00
!RSPHERE:  2.91548E+00
!RADIUS :  1.45774E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.13704E+01
!FAR    :  2.04083E+01
SCEN GEOM NAVI FREE
          FACE SBAC
     ISO  FILL FIEL PFSI SCAL USER PROG -0.4E5 PAS 0.2E5 2.2E5 TERM
          SUPP LECT visu TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 10 KFRE 10 COMP -1
     OBJE LECT visu TERM REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL
     OBJE LECT visu TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT visu TERM REND
ENDPLAY
*=====================================================================
SUIT
Post-treatment
RESU ALIC GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE  -2.76637E-01 -9.06588E+00  7.63759E+00
!        Q     8.19005E-01  5.44625E-01 -1.00078E-01 -1.50329E-01
         VIEW  3.27675E-01  8.62012E-01 -3.86736E-01
         RIGH  9.34771E-01 -3.55251E-01  1.82185E-04
         UP    1.37231E-01  3.61569E-01  9.22191E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  4.50000E+00  3.50000E+00  2.00000E+00
!RSPHERE:  2.91548E+00
!RADIUS :  1.45774E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.13704E+01
!FAR    :  2.04083E+01
```

```
SCEN GEOM NAVI FREE
          FACE SBAC
     ISO  FILL FIEL PFMA SCAL USER PROG -0.4E5 PAS 0.2E5 2.2E5 TERM
          SUPP LECT visu TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 10 KFRE 10 COMP -1
     OBJE LECT visu TERM REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL
     OBJE LECT visu TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT visu TERM REND
ENDPLAY
*=======================================================================
SUIT
Post-treatment
RESU ALIC GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=======================================================================
PLAY
CAME   1 EYE  -2.76637E-01 -9.06588E+00  7.63759E+00
!        Q     8.19005E-01  5.44625E-01 -1.00078E-01 -1.50329E-01
         VIEW  3.27675E-01  8.62012E-01 -3.86736E-01
         RIGH  9.34771E-01 -3.55251E-01  1.82185E-04
         UP    1.37231E-01  3.61569E-01  9.22191E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  4.50000E+00  3.50000E+00  2.00000E+00
!RSPHERE:  2.91548E+00
!RADIUS :  1.45774E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.13704E+01
!FAR    :  2.04083E+01
SCEN GEOM NAVI FREE
          FACE SBAC
     ISO  FILL FIEL PFMI SCAL USER PROG -0.4E5 PAS 0.2E5 2.2E5 TERM
          SUPP LECT visu TERM
          COSC ICOL ! Invert colors scale
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 10 KFRE 10 COMP -1
     OBJE LECT visu TERM REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL
     OBJE LECT visu TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT visu TERM REND
ENDPLAY
*=======================================================================
FIN
```

visu08.dgibi

```
opti echo 1;
opti dime 3 elem cub8;
*
************************************************************************
'DEBPROC' pxbox3d x0*'FLOTTANT' y0*'FLOTTANT' z0*'FLOTTANT'
                  lx*'FLOTTANT' ly*'FLOTTANT' lz*'FLOTTANT'
                  dd*'FLOTTANT';
*
*-------------------------------------------------
* Generates a parallelepiped mesh with origin in point
* (x0,y0,z0), sides of length (lx,ly,lz) and density (mesh size) dd.
* The mesh consists of CUB8 hexahedral elements and is oriented
* along the global axes.
*
* Input :
* -----
*     x0,y0,z0 : coordinates of 'origin' of the box
*     lx,ly,lz : length of the box sides
*     dd : "density" (size) of the mesh (the same in all directions)
* Output :
* ------
*     box : mesh consisting of CUB8 hexahedra
*-------------------------------------------------
*
dens dd;
p1 = x0 y0 z0;
p2 = (x0 + lx) y0 z0;
p3 = (x0 + lx) (y0 + ly) z0;
p4 = x0 (y0 + ly) z0;
*
c1 = p1 d p2;
c2 = p2 d p3;
c3 = p3 d p4;
c4 = p4 d p1;
base = dall c1 c2 c3 c4 plan;
*
box = base volu tran (0 0 lz);
*
finproc box;
************************************************************************
*
opti trac psc ftra 'visu08_mesh.ps';
opti sauv form 'visu08.msh';
*
* Mesh size
*
den = 0.05;
tol = 0.001;
*
* Atmosphere
flui = pxbox3d   0    0    0    1    1    1 den;
list (nbel flui);
*
* Building
p1 = 0.5 0.1 0.1;
p2 = 0.5 0.1 0.9;
p3 = 0.5 0.9 0.9;
p4 = 0.5 0.9 0.1;
c1 = p1 d 4 p2;
c2 = p2 d 4 p3;
c3 = p3 d 4 p4;
c4 = p4 d 4 p1;
buil = dall c1 c2 c3 c4 plan;
*
trac cach qual flui;
lines = (aret flui) et (cont buil);
trac qual lines;
*
visu = (buil coul vert) orie poin (1.0 0.5 0.5);
trac cach qual visu;
*
mesh = flui et buil et visu;
tass mesh noop;
sauv form mesh;
*
fin;
```

visu08.epx

```
VISU08
ECHO
 CONV WIN
CAST mesh
TRID ALE
DIME NALE 1 NBLE 1 TERM
GEOM CUVF flui
     Q4GS buil
     CL3Q visu TERM
COMP EPAI 0.01 LECT buil TERM
     GROU 2 'expl' LECT flui TERM COND XB LT 0.4
            'air'  LECT flui DIFF expl TERM
     COUL ROUG LECT expl TERM
          TURQ LECT air  TERM
          ROSE LECT buil TERM
          VERT LECT visu TERM
GRIL LAGR LECT buil TERM
     EULE LECT flui TERM
MATE GAZP RO 100 GAMMA 1.4 PINI 100E5 PREF 1E5
          LECT expl TERM
     GAZP RO 1 GAMMA 1.4 PINI 1E5 PREF 1E5
          LECT air  TERM
     VM23 RO 7800. YOUNG 1.6E11 NU 0.333 ELAS 1.05E8
          TRAC 2 1.05E8 .656256E-3 1.6105E10 1.00066
          LECT buil TERM
     IMPE VISU DECO
          LECT visu TERM
LINK DECO FLSW STRU LECT buil TERM
               FLUI LECT flui TERM
               R    0.0435 ! Radius of influence fluid-structure
                           ! >= 0.87 * dens fluid
               HGRI 0.2500 ! Grid: slightly bigger than the biggest
                           ! structural element
               DGRI
               FACE
               BFLU 2 FSCP 1
ECRI ECRO VFCC FREQ 20
     FICH ALIC FREQ 1
OPTI NOTE LOG 1
     PAS UTIL
     NOCR LECT buil TERM
     VFCC NTIL
CALC TINI 0.0 TFIN 40.E-3 PASF 0.5E-4 NMAX 100
fin




*=======================================================================
PLAY
CAME   1 EYE  -2.76637E-01 -9.06588E+00  7.63759E+00
!        Q     8.19005E-01  5.44625E-01 -1.00078E-01 -1.50329E-01
         VIEW  3.27675E-01  8.62012E-01 -3.86736E-01
         RIGH  9.34771E-01 -3.55251E-01  1.82185E-04
         UP    1.37231E-01  3.61569E-01  9.22191E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  4.50000E+00  3.50000E+00  2.00000E+00
!RSPHERE:  2.91548E+00
!RADIUS :  1.45774E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.13704E+01
!FAR    :  2.04083E+01
SCEN GEOM NAVI FREE
          FACE SBAC
     ISO  FILL FIEL PFSI SCAL USER PROG -0.4E5 PAS 0.2E5 2.2E5 TERM
          SUPP LECT visu TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 10 KFRE 10 COMP -1
     OBJE LECT visu TERM REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL
     OBJE LECT visu TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT visu TERM REND
ENDPLAY
*=======================================================================
fin



!SUIT
!Post-treatment
!RESU ALIC GARD PSCR
!OPTI PRIN
!SORT VISU NSTO 1
*=======================================================================
!PLAY
!CAME   1 EYE  -2.76637E-01 -9.06588E+00  7.63759E+00
```

```
!!        Q     8.19005E-01  5.44625E-01 -1.00078E-01 -1.50329E-01
!         VIEW  3.27675E-01  8.62012E-01 -3.86736E-01
!         RIGH  9.34771E-01 -3.55251E-01  1.82185E-04
!         UP    1.37231E-01  3.61569E-01  9.22191E-01
!         FOV   2.48819E+01
!!NAVIGATION MODE: ROTATING CAMERA
!!CENTER :  4.50000E+00  3.50000E+00  2.00000E+00
!!RSPHERE:  2.91548E+00
!!RADIUS :  1.45774E+01
!!ASPECT :  1.00000E+00
!!NEAR   :  1.13704E+01
!!FAR    :  2.04083E+01
!SCEN GEOM NAVI FREE
!          FACE SBAC
!     ISO  FILL FIEL ECRO 1 SCAL USER PROG 0.6E5 PAS 0.2E5 3.2E5 TERM
!          SUPP LECT flui TERM
!     TEXT ISCA
!     COLO PAPE
!SLER CAM1 1 NFRA 1
!TRAC OFFS FICH AVI NOCL NFTO 101 FPS 10 KFRE 10 COMP -1
!     OBJE LECT flui abso TERM REND
!FREQ 1
!GOTR LOOP 99 OFFS FICH AVI CONT NOCL
!     OBJE LECT flui abso TERM REND
!GO
!TRAC OFFS FICH AVI CONT
!     OBJE LECT flui abso TERM REND
!ENDPLAY
SUIT
Post-treatment
RESU ALIC GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*======================================================================
PLAY
CAME   1 EYE  -2.76637E-01 -9.06588E+00  7.63759E+00
!        Q     8.19005E-01  5.44625E-01 -1.00078E-01 -1.50329E-01
         VIEW  3.27675E-01  8.62012E-01 -3.86736E-01
         RIGH  9.34771E-01 -3.55251E-01  1.82185E-04
         UP    1.37231E-01  3.61569E-01  9.22191E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  4.50000E+00  3.50000E+00  2.00000E+00
!RSPHERE:  2.91548E+00
!RADIUS :  1.45774E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.13704E+01
!FAR    :  2.04083E+01
SCEN GEOM NAVI FREE
     ISO  FILL FIEL PFMA SCAL USER PROG -0.4E5 PAS 0.2E5 2.2E5 TERM
          SUPP LECT visu TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 10 KFRE 10 COMP -1
     OBJE LECT visu TERM REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL
     OBJE LECT visu TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT visu TERM REND
ENDPLAY
*======================================================================
SUIT
Post-treatment
RESU ALIC GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*======================================================================
PLAY
CAME   1 EYE  -2.76637E-01 -9.06588E+00  7.63759E+00
!        Q     8.19005E-01  5.44625E-01 -1.00078E-01 -1.50329E-01
         VIEW  3.27675E-01  8.62012E-01 -3.86736E-01
         RIGH  9.34771E-01 -3.55251E-01  1.82185E-04
         UP    1.37231E-01  3.61569E-01  9.22191E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  4.50000E+00  3.50000E+00  2.00000E+00
!RSPHERE:  2.91548E+00
!RADIUS :  1.45774E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.13704E+01
!FAR    :  2.04083E+01
SCEN GEOM NAVI FREE
     ISO  FILL FIEL PFMI SCAL USER PROG -0.4E5 PAS 0.2E5 2.2E5 TERM
          SUPP LECT visu TERM
          COSC ICOL ! Invert colors scale
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 101 FPS 10 KFRE 10 COMP -1
     OBJE LECT visu TERM REND
FREQ 1
GOTR LOOP 99 OFFS FICH AVI CONT NOCL
     OBJE LECT visu TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT visu TERM REND
ENDPLAY
*======================================================================
FIN
```

visu09.dgibi

```
opti echo 1;
opti dime 3 elem cub8;
*
***********************************************************************
'DEBPROC' pxbox3d x0*'FLOTTANT' y0*'FLOTTANT' z0*'FLOTTANT'
                  lx*'FLOTTANT' ly*'FLOTTANT' lz*'FLOTTANT'
                  dd*'FLOTTANT';
*
*------------------------------------------------
* Generates a parallelepiped mesh with origin in point
* (x0,y0,z0), sides of length (lx,ly,lz) and density (mesh size) dd.
* The mesh consists of CUB8 hexahedral elements and is oriented
* along the global axes.
*
* Input :
* -----
*     x0,y0,z0 : coordinates of 'origin' of the box
*     lx,ly,lz : length of the box sides
*     dd : "density" (size) of the mesh (the same in all directions)
* Output :
* ------
*     box : mesh consisting of CUB8 hexahedra
*------------------------------------------------
*
dens dd;
p1 = x0 y0 z0;
p2 = (x0 + lx) y0 z0;
p3 = (x0 + lx) (y0 + ly) z0;
p4 = x0 (y0 + ly) z0;
*
c1 = p1 d p2;
c2 = p2 d p3;
c3 = p3 d p4;
c4 = p4 d p1;
base = dall c1 c2 c3 c4 plan;
*
box = base volu tran (0 0 lz);
*
finproc box;
*
***********************************************************************
'DEBPROC' pxsbox3d x0*'FLOTTANT' y0*'FLOTTANT' z0*'FLOTTANT'
                   lx*'FLOTTANT' ly*'FLOTTANT' lz*'FLOTTANT'
                   dd*'FLOTTANT';
*
*------------------------------------------------
* Generates a structure box mesh with origin in point
* (x0,y0,z0), sides of length (lx,ly,lz) and density (mesh size) dd.
* The mesh consists of QUA4 quadrilateral elements and is oriented
* along the global axes.
* The box has solid "walls" and a solid "roof" but an empty "base",
* thus resembling a sort of building.
*
* Input :
* -----
*     x0,y0,z0 : coordinates of 'origin' of the box
*     lx,ly,lz : length of the box sides
*     dd : "density" (size) of the mesh (the same in all directions)
* Output :
* ------
*     box : mesh consisting of QUA4 quadrilaterals
*------------------------------------------------
*
dens dd;
p1 = x0 y0 z0;
p2 = (x0 + lx) y0 z0;
p3 = (x0 + lx) (y0 + ly) z0;
p4 = x0 (y0 + ly) z0;
*
c1 = p1 d p2;
c2 = p2 d p3;
c3 = p3 d p4;
c4 = p4 d p1;
roof = (dall c1 c2 c3 c4 plan) plus (0 0 lz);
*
peri = c1 et c2 et c3 et c4;
slat = tran peri (0 0 lz);
*
box = slat et roof;
tol = dd * 0.01;
elim tol box;
*
finproc box;
***********************************************************************
*
opti trac psc ftra 'visu09_mesh.ps';
opti sauv form 'visu09.msh';
*
* Mesh size
*
den = 1.0;
tol = 0.01;
*
* Atmosphere
flui = pxbox3d   0   0   0   8   6   6 den;
list (nbel flui);
*
* Building
buil = pxsbox3d   3   2   0   3   3   4 den;
*
*list (nbel flui);
*
trac cach qual flui;
lines = aret flui;
trac qual lines;
*
* Absorbing boundary
*
ba = bary flui;
*
abstop = (face 2 flui) orie poin ba;
abslat = (face 3 flui) orie poin ba;
trac cach qual abstop;
trac cach qual abslat;
abso = abstop et abslat;
trac cach qual abso;
*
visu = (buil coul vert) orie poin (bary buil);
trac cach qual visu;
*
mesh = flui et buil et abso et visu;
tass mesh noop;
sauv form mesh;
*
fin;
```

visu09.epx

```
VISU09
ECHO
!CONV WIN
CAST mesh
TRID ALE
DIME ADAP NPOI 5167 CUVF 4688 CL3D 100 NVFI 15444 ENDA
     NALE 1 NBLE 1 TERM
GEOM CUVF flui
     Q4GS buil
     CL3D abso
     CL3Q visu TERM
COMP EPAI 0.1 LECT buil TERM
     GROU 2 'expl' LECT flui TERM COND NEAR POIN 0 0 0
            'air'  LECT flui DIFF expl TERM
     COUL ROUG LECT expl TERM
          TURQ LECT air  TERM
          ROSE LECT buil TERM
          JAUN LECT abso TERM
          VERT LECT visu TERM
GRIL LAGR LECT buil TERM
     EULE LECT flui TERM
MATE GAZP RO 100 GAMMA 1.4 PINI 100E5 PREF 1E5
          LECT expl TERM
     GAZP RO 1 GAMMA 1.4 PINI 1E5 PREF 1E5
          LECT air _cuvf TERM
     VM23 RO 7800. YOUNG 1.6E11 NU 0.333 ELAS 1.05E8
          TRAC 2 1.05E8 .656256E-3 1.6105E10 1.00066
          LECT buil TERM
     CLVF ABSO RO 1 LECT abso _cl3d TERM
     IMPE VISU DECO
          LECT visu TERM
LINK COUP SPLT NONE
          BLOQ 123456 LECT buil TERM
LINK DECO FLSW STRU LECT buil TERM
               FLUI LECT flui TERM
               R    0.870 ! Radius of influence fluid-structure
                          ! >= 0.87 * dens fluid
               HGRI 1.500 ! Grid: slightly bigger than the biggest
                          ! structural element
               DGRI
               FACE
               BFLU 2 FSCP 1
               ADAP LMAX 3
ECRI ECRO VFCC FREQ 40
     FICH ALIC FREQ 1
OPTI NOTE LOG 1
     PAS UTIL
     NOCR LECT buil TERM
     VFCC NTIL
     ADAP RCON
CALC TINI 0.0 TFIN 40.E-3 PASF 0.2E-3 NMAX 200
*=====================================================================
PLAY
CAME   1 EYE  -2.76637E-01 -9.06588E+00  7.63759E+00
!        Q     8.19005E-01  5.44625E-01 -1.00078E-01 -1.50329E-01
         VIEW  3.27675E-01  8.62012E-01 -3.86736E-01
         RIGH  9.34771E-01 -3.55251E-01  1.82185E-04
         UP    1.37231E-01  3.61569E-01  9.22191E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  4.50000E+00  3.50000E+00  2.00000E+00
!RSPHERE:  2.91548E+00
!RADIUS :  1.45774E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.13704E+01
!FAR    :  2.04083E+01
SCEN GEOM NAVI FREE
          FACE SBAC
     ISO  FILL FIEL PFSI SCAL USER PROG -0.2E5 PAS 0.2E5 2.4E5 TERM
          SUPP LECT visu TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 10 KFRE 10 COMP -1
     OBJE LECT visu TERM REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL
     OBJE LECT visu TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT visu TERM REND
ENDPLAY
*=====================================================================
SUIT
Post-treatment
RESU ALIC GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE  -2.76637E-01 -9.06588E+00  7.63759E+00
!        Q     8.19005E-01  5.44625E-01 -1.00078E-01 -1.50329E-01
         VIEW  3.27675E-01  8.62012E-01 -3.86736E-01
         RIGH  9.34771E-01 -3.55251E-01  1.82185E-04
         UP    1.37231E-01  3.61569E-01  9.22191E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  4.50000E+00  3.50000E+00  2.00000E+00
!RSPHERE:  2.91548E+00
!RADIUS :  1.45774E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.13704E+01
!FAR    :  2.04083E+01
SCEN GEOM NAVI FREE
          FACE HFRO
     VECT SCCO FIEL FDEC SCAL USER PROG 0.2E5 PAS 0.2E5 2.8E5 TERM
          SUPP LECT visu TERM
          LENG 5
     TEXT VSCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 10 KFRE 10 COMP -1
     OBJE LECT visu TERM REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL
     OBJE LECT visu TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT visu TERM REND
ENDPLAY
SUIT
Post-treatment
RESU ALIC GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE  -2.76637E-01 -9.06588E+00  7.63759E+00
!        Q     8.19005E-01  5.44625E-01 -1.00078E-01 -1.50329E-01
         VIEW  3.27675E-01  8.62012E-01 -3.86736E-01
         RIGH  9.34771E-01 -3.55251E-01  1.82185E-04
         UP    1.37231E-01  3.61569E-01  9.22191E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  4.50000E+00  3.50000E+00  2.00000E+00
!RSPHERE:  2.91548E+00
!RADIUS :  1.45774E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.13704E+01
!FAR    :  2.04083E+01
SCEN GEOM NAVI FREE
          FACE SBAC
     ISO  FILL FIEL PFMA SCAL USER PROG -0.2E5 PAS 0.2E5 2.4E5 TERM
          SUPP LECT visu TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 10 KFRE 10 COMP -1
     OBJE LECT visu TERM REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL
     OBJE LECT visu TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT visu TERM REND
ENDPLAY
*=====================================================================
SUIT
Post-treatment
RESU ALIC GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE  -2.76637E-01 -9.06588E+00  7.63759E+00
!        Q     8.19005E-01  5.44625E-01 -1.00078E-01 -1.50329E-01
         VIEW  3.27675E-01  8.62012E-01 -3.86736E-01
         RIGH  9.34771E-01 -3.55251E-01  1.82185E-04
         UP    1.37231E-01  3.61569E-01  9.22191E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  4.50000E+00  3.50000E+00  2.00000E+00
!RSPHERE:  2.91548E+00
!RADIUS :  1.45774E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.13704E+01
!FAR    :  2.04083E+01
SCEN GEOM NAVI FREE
          FACE SBAC
     ISO  FILL FIEL PFMI SCAL USER PROG -0.2E5 PAS 0.2E5 2.4E5 TERM
          SUPP LECT visu TERM
          COSC ICOL ! Invert colors scale
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 10 KFRE 10 COMP -1
     OBJE LECT visu TERM REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL
     OBJE LECT visu TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT visu TERM REND
ENDPLAY
*=====================================================================
FIN
```

visu09a.epx

```
VISU09A
ECHO
RESU ALIC 'visu09.ali' GARD PSCR
COMP NGRO 1 'n502' LECT visu TERM COND NEAR POIN 4 3 4
OPTI PRIN
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'pfsi_502' PFSI NOEU LECT n502 TERM
COUR 2 'pfmi_502' PFMI NOEU LECT n502 TERM
COUR 3 'pfma_502' PFMA NOEU LECT n502 TERM
TRAC 1 2 3 AXES 1.0 'PFSI [PA]' YZER
COLO NOIR VERT ROUG
QUAL PFSI COMP 1 LECT n502 TERM REFE  0.00000E+0 TOLE 1.E-2
     PFMI COMP 1 LECT n502 TERM REFE  0.00000E+0 TOLE 1.E-2
     PFMA COMP 1 LECT n502 TERM REFE  0.00000E+0 TOLE 1.E-2
FIN
```

visu09b.epx

```
VISU09B
ECHO
RESU ALIC 'visu09.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=====================================================================
PLAY
CAME   1 EYE  -2.76637E-01 -9.06588E+00  7.63759E+00
!        Q     8.19005E-01  5.44625E-01 -1.00078E-01 -1.50329E-01
```

```
        VIEW  3.27675E-01  8.62012E-01 -3.86736E-01
        RIGH  9.34771E-01 -3.55251E-01  1.82185E-04
        UP    1.37231E-01  3.61569E-01  9.22191E-01
        FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  4.50000E+00  3.50000E+00  2.00000E+00
!RSPHERE:  2.91548E+00
!RADIUS :  1.45774E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.13704E+01
!FAR    :  2.04083E+01
SCEN OBJE SELV FLSW
     GEOM NAVI FREE
          FACE SBAC SINT
     ISO  FILL FIEL ECRO 1 SCAL USER PROG 0.8E5 PAS 0.2E5 3.4E5 TERM
          SUPP LECT flui TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 10 KFRE 10 COMP -1
     REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL
     REND
GO
TRAC OFFS FICH AVI CONT
     REND
ENDPLAY
FIN
```

visu09c.epx

```
VISU09C
ECHO
RESU ALIC 'visu09.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=======================================================================
PLAY
CAME   1 EYE  -2.76637E-01 -9.06588E+00  7.63759E+00
!        Q     8.19005E-01  5.44625E-01 -1.00078E-01 -1.50329E-01
        VIEW  3.27675E-01  8.62012E-01 -3.86736E-01
        RIGH  9.34771E-01 -3.55251E-01  1.82185E-04
        UP    1.37231E-01  3.61569E-01  9.22191E-01
        FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  4.50000E+00  3.50000E+00  2.00000E+00
!RSPHERE:  2.91548E+00
!RADIUS :  1.45774E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.13704E+01
!FAR    :  2.04083E+01
SCEN GEOM NAVI FREE
          FACE SBAC
     ISO  FILL FIEL FDEC SCAL USER PROG 0.2E5 PAS 0.2E5 2.8E5 TERM
          SUPP LECT buil TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 10 KFRE 10 COMP -1
     OBJE LECT buil TERM REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL
     OBJE LECT buil TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT buil TERM REND
ENDPLAY
FIN
```

visu10.dgibi

```
opti echo 1;
opti dime 3 elem cub8;
*
************************************************************************
'DEBPROC' pxbox3d x0*'FLOTTANT' y0*'FLOTTANT' z0*'FLOTTANT'
                  lx*'FLOTTANT' ly*'FLOTTANT' lz*'FLOTTANT'
                  dd*'FLOTTANT';
*
*-------------------------------------------------
* Generates a parallelepiped mesh with origin in point
* (x0,y0,z0), sides of length (lx,ly,lz) and density (mesh size) dd.
* The mesh consists of CUB8 hexahedral elements and is oriented
* along the global axes.
*
* Input :
* -----
*     x0,y0,z0 : coordinates of 'origin' of the box
*     lx,ly,lz : length of the box sides
*     dd : "density" (size) of the mesh (the same in all directions)
* Output :
* ------
*     box : mesh consisting of CUB8 hexahedra
*-------------------------------------------------
*
dens dd;
p1 = x0 y0 z0;
p2 = (x0 + lx) y0 z0;
p3 = (x0 + lx) (y0 + ly) z0;
p4 = x0 (y0 + ly) z0;
*
c1 = p1 d p2;
c2 = p2 d p3;
c3 = p3 d p4;
c4 = p4 d p1;
base = dall c1 c2 c3 c4 plan;
*
box = base volu tran (0 0 lz);
*
finproc box;
*
************************************************************************
'DEBPROC' pxsbox3d x0*'FLOTTANT' y0*'FLOTTANT' z0*'FLOTTANT'
                   lx*'FLOTTANT' ly*'FLOTTANT' lz*'FLOTTANT'
                   dd*'FLOTTANT';
*
*-------------------------------------------------
* Generates a structure box mesh with origin in point
* (x0,y0,z0), sides of length (lx,ly,lz) and density (mesh size) dd.
* The mesh consists of QUA4 quadrilateral elements and is oriented
* along the global axes.
* The box has solid "walls" and a solid "roof" but an empty "base",
* thus resembling a sort of building.
*
* Input :
* -----
*     x0,y0,z0 : coordinates of 'origin' of the box
*     lx,ly,lz : length of the box sides
*     dd : "density" (size) of the mesh (the same in all directions)
* Output :
* ------
*     box : mesh consisting of QUA4 quadrilaterals
*-------------------------------------------------
*
dens dd;
p1 = x0 y0 z0;
p2 = (x0 + lx) y0 z0;
p3 = (x0 + lx) (y0 + ly) z0;
p4 = x0 (y0 + ly) z0;
*
c1 = p1 d p2;
c2 = p2 d p3;
c3 = p3 d p4;
c4 = p4 d p1;
roof = (dall c1 c2 c3 c4 plan) plus (0 0 lz);
*
peri = c1 et c2 et c3 et c4;
slat = tran peri (0 0 lz);
*
box = slat et roof;
tol = dd * 0.01;
elim tol box;
*
finproc box;
************************************************************************
*
opti trac psc ftra 'visu10_mesh.ps';
opti sauv form 'visu10.msh';
*
* Mesh size
*
den = 0.5;
tol = 0.005;
*
* Atmosphere
flui = pxbox3d   0   0   0   8   6   6 den;
list (nbel flui);
*
* Building
buil = pxsbox3d   3   2   0   3   3   4 den;
*
*list (nbel flui);
*
trac cach qual flui;
lines = aret flui;
trac qual lines;
*
* Absorbing boundary
*
ba = bary flui;
*
abstop = (face 2 flui) orie poin ba;
abslat = (face 3 flui) orie poin ba;
trac cach qual abstop;
trac cach qual abslat;
abso = abstop et abslat;
trac cach qual abso;
*
visu = (buil coul vert) orie poin (bary buil);
trac cach qual visu;
*
mesh = flui et buil et abso et visu;
tass mesh noop;
sauv form mesh;
*
fin;
```

visu10.epx

```
VISU10
ECHO
!CONV WIN
CAST mesh
TRID ALE
DIME ADAP NPOI 19828 CUVF 18368 NVFI 60048 ENDA
     NALE 1 NBLE 1 TERM
GEOM CUVF flui
     Q4GS buil
     CL3D abso
     CL3Q visu TERM
COMP EPAI 0.1 LECT buil TERM
     GROU 2 'expl' LECT flui TERM COND BOX X0 0 Y0 0 Z0 0
                                            DX 1 DY 1 DZ 1
          'air'  LECT flui DIFF expl TERM
     COUL ROUG LECT expl TERM
          TURQ LECT air  TERM
          ROSE LECT buil TERM
          JAUN LECT abso TERM
          VERT LECT visu TERM
GRIL LAGR LECT buil TERM
     EULE LECT flui TERM
MATE GAZP RO 100 GAMMA 1.4 PINI 100E5 PREF 1E5
          LECT expl TERM
     GAZP RO 1 GAMMA 1.4 PINI 1E5 PREF 1E5
          LECT air _cuvf TERM
     VM23 RO 7800. YOUNG 1.6E11 NU 0.333 ELAS 1.05E8
          TRAC 2 1.05E8 .656256E-3 1.6105E10 1.00066
          LECT buil TERM
```

```
     CLVF ABSO RO 1 LECT abso TERM
     IMPE VISU DECO
          LECT visu TERM
LINK COUP SPLT NONE
          BLOQ 123456 LECT buil TERM
LINK DECO FLSW STRU LECT buil TERM
               FLUI LECT flui TERM
               R    0.435 ! Radius of influence fluid-structure
                          ! >= 0.87 * dens fluid
               HGRI 0.750 ! Grid: slightly bigger than the biggest
                          ! structural element
               DGRI
               FACE
               BFLU 2 FSCP 1
               ADAP LMAX 3
ECRI ECRO VFCC FREQ 80
     FICH ALIC FREQ 1
OPTI NOTE LOG 1
     PAS UTIL
     NOCR LECT buil TERM
     VFCC NTIL
     ADAP RCON
CALC TINI 0.0 TFIN 40.E-3 PASF 0.1E-3 NMAX 400
*=======================================================================
PLAY
CAME   1 EYE  -2.76637E-01 -9.06588E+00  7.63759E+00
!        Q     8.19005E-01  5.44625E-01 -1.00078E-01 -1.50329E-01
         VIEW  3.27675E-01  8.62012E-01 -3.86736E-01
         RIGH  9.34771E-01 -3.55251E-01  1.82185E-04
         UP    1.37231E-01  3.61569E-01  9.22191E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  4.50000E+00  3.50000E+00  2.00000E+00
!RSPHERE:  2.91548E+00
!RADIUS :  1.45774E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.13704E+01
!FAR    :  2.04083E+01
SCEN GEOM NAVI FREE
          FACE SBAC
     ISO  FILL FIEL PFSI SCAL USER PROG -0.2E5 PAS 0.2E5 2.4E5 TERM
          SUPP LECT visu TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 401 FPS 10 KFRE 10 COMP -1
     OBJE LECT visu TERM REND
FREQ 1
GOTR LOOP 399 OFFS FICH AVI CONT NOCL
     OBJE LECT visu TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT visu TERM REND
ENDPLAY
*=======================================================================
SUIT
Post-treatment
RESU ALIC GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=======================================================================
PLAY
CAME   1 EYE  -2.76637E-01 -9.06588E+00  7.63759E+00
!        Q     8.19005E-01  5.44625E-01 -1.00078E-01 -1.50329E-01
         VIEW  3.27675E-01  8.62012E-01 -3.86736E-01
         RIGH  9.34771E-01 -3.55251E-01  1.82185E-04
         UP    1.37231E-01  3.61569E-01  9.22191E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  4.50000E+00  3.50000E+00  2.00000E+00
!RSPHERE:  2.91548E+00
!RADIUS :  1.45774E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.13704E+01
!FAR    :  2.04083E+01
SCEN GEOM NAVI FREE
          FACE HFRO
     VECT SCCO FIEL FDEC SCAL USER PROG 0.2E5 PAS 0.2E5 2.8E5 TERM
          SUPP LECT visu TERM
          LENG 5
     TEXT VSCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 401 FPS 10 KFRE 10 COMP -1
     OBJE LECT visu TERM REND
FREQ 1
GOTR LOOP 399 OFFS FICH AVI CONT NOCL
     OBJE LECT visu TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT visu TERM REND
ENDPLAY
SUIT
Post-treatment
RESU ALIC GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=======================================================================
PLAY
CAME   1 EYE  -2.76637E-01 -9.06588E+00  7.63759E+00
!        Q     8.19005E-01  5.44625E-01 -1.00078E-01 -1.50329E-01
         VIEW  3.27675E-01  8.62012E-01 -3.86736E-01
         RIGH  9.34771E-01 -3.55251E-01  1.82185E-04
         UP    1.37231E-01  3.61569E-01  9.22191E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  4.50000E+00  3.50000E+00  2.00000E+00
!RSPHERE:  2.91548E+00
!RADIUS :  1.45774E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.13704E+01
!FAR    :  2.04083E+01
SCEN GEOM NAVI FREE
          FACE SBAC
     ISO  FILL FIEL PFMA SCAL USER PROG -0.2E5 PAS 0.2E5 2.4E5 TERM
          SUPP LECT visu TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 401 FPS 10 KFRE 10 COMP -1
     OBJE LECT visu TERM REND
FREQ 1
GOTR LOOP 399 OFFS FICH AVI CONT NOCL
     OBJE LECT visu TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT visu TERM REND
ENDPLAY
*=======================================================================
SUIT
Post-treatment
RESU ALIC GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=======================================================================
PLAY
CAME   1 EYE  -2.76637E-01 -9.06588E+00  7.63759E+00
!        Q     8.19005E-01  5.44625E-01 -1.00078E-01 -1.50329E-01
         VIEW  3.27675E-01  8.62012E-01 -3.86736E-01
         RIGH  9.34771E-01 -3.55251E-01  1.82185E-04
         UP    1.37231E-01  3.61569E-01  9.22191E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  4.50000E+00  3.50000E+00  2.00000E+00
!RSPHERE:  2.91548E+00
!RADIUS :  1.45774E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.13704E+01
!FAR    :  2.04083E+01
SCEN GEOM NAVI FREE
          FACE SBAC
     ISO  FILL FIEL PFMI SCAL USER PROG -0.2E5 PAS 0.2E5 2.4E5 TERM
          SUPP LECT visu TERM
          COSC ICOL ! Invert colors scale
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 401 FPS 10 KFRE 10 COMP -1
     OBJE LECT visu TERM REND
FREQ 1
GOTR LOOP 399 OFFS FICH AVI CONT NOCL
     OBJE LECT visu TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT visu TERM REND
ENDPLAY
*=======================================================================
FIN
```

visu10a.epx

```
VISU10A
ECHO
RESU ALIC 'visu10.ali' GARD PSCR
COMP NGRO 1 'n502' LECT visu TERM COND NEAR POIN 4 3 4
OPTI PRIN
SORT GRAP
AXTE 1.0 'Time [s]'
COUR 1 'pfsi_502' PFSI NOEU LECT n502 TERM
COUR 2 'pfmi_502' PFMI NOEU LECT n502 TERM
COUR 3 'pfma_502' PFMA NOEU LECT n502 TERM
TRAC 1 2 3 AXES 1.0 'PFSI [PA]' YZER
COLO NOIR VERT ROUG
QUAL PFSI COMP 1 LECT n502 TERM REFE  0.00000E+0 TOLE 1.E-2
     PFMI COMP 1 LECT n502 TERM REFE  0.00000E+0 TOLE 1.E-2
     PFMA COMP 1 LECT n502 TERM REFE  0.00000E+0 TOLE 1.E-2
FIN
```

visu10b.epx

```
VISU10B
ECHO
RESU ALIC 'visu10.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=======================================================================
PLAY
CAME   1 EYE  -2.76637E-01 -9.06588E+00  7.63759E+00
!        Q     8.19005E-01  5.44625E-01 -1.00078E-01 -1.50329E-01
         VIEW  3.27675E-01  8.62012E-01 -3.86736E-01
         RIGH  9.34771E-01 -3.55251E-01  1.82185E-04
         UP    1.37231E-01  3.61569E-01  9.22191E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  4.50000E+00  3.50000E+00  2.00000E+00
!RSPHERE:  2.91548E+00
!RADIUS :  1.45774E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.13704E+01
!FAR    :  2.04083E+01
SCEN OBJE SELV FLSW
     GEOM NAVI FREE
          FACE SBAC SINT
     ISO  FILL FIEL ECRO 1 SCAL USER PROG 0.8E5 PAS 0.2E5 3.4E5 TERM
          SUPP LECT flui TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 401 FPS 10 KFRE 10 COMP -1
     REND
FREQ 1
GOTR LOOP 399 OFFS FICH AVI CONT NOCL
     REND
GO
TRAC OFFS FICH AVI CONT
     REND
ENDPLAY
FIN
```

visu10c.epx

```
VISU10C
ECHO
RESU ALIC 'visu10.ali' GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*======================================================================
PLAY
CAME   1 EYE  -2.76637E-01 -9.06588E+00  7.63759E+00
!        Q      8.19005E-01  5.44625E-01 -1.00078E-01 -1.50329E-01
         VIEW  3.27675E-01  8.62012E-01 -3.86736E-01
         RIGH  9.34771E-01 -3.55251E-01  1.82185E-04
         UP    1.37231E-01  3.61569E-01  9.22191E-01
         FOV   2.48819E+01
!NAVIGATION MODE: ROTATING CAMERA
!CENTER :  4.50000E+00  3.50000E+00  2.00000E+00
!RSPHERE:  2.91548E+00
!RADIUS :  1.45774E+01
!ASPECT :  1.00000E+00
!NEAR   :  1.13704E+01
!FAR    :  2.04083E+01
SCEN GEOM NAVI FREE
          FACE SBAC
     ISO  FILL FIEL FDEC SCAL USER PROG 0.05E5 PAS 0.05E5 0.7E5 TERM
          SUPP LECT buil TERM
     TEXT ISCA
     COLO PAPE
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 401 FPS 10 KFRE 10 COMP -1
     OBJE LECT buil TERM REND
FREQ 1
GOTR LOOP 399 OFFS FICH AVI CONT NOCL
     OBJE LECT buil TERM REND
GO
TRAC OFFS FICH AVI CONT
     OBJE LECT buil TERM REND
ENDPLAY
FIN
```

List of input files

European Commission
EUR 27207 EN – Joint Research Centre – Institute for the Protection and Security of the Citizen

Title: Visulization of Fluid-Structure Interaction Pressure acting on Structures with EUROPLEXUS

Author(s): Folco Casadei, Martin Larcher, Georgios Valsamos

Luxembourg: Publications Office of the European Union

2015 – 40 pp. – 21.0 x 29.7 cm

EUR – Scientific and Technical Research series – ISSN 1831-9424 (online)

ISBN 978-92-79-47751-5 (PDF)

doi:10.2788/777426

Abstract

This report describes the implementation of a method for the visualization of fluid pressures acting on structures computed by various Fluid-Structure Interaction (FSI) approaches in EUROPLEXUS

LB-NA-27207-EN-N

JRC Mission

As the Commission's in-house science service, the Joint Research Centre's mission is to provide EU policies with independent, evidence-based scientific and technical support throughout the whole policy cycle.

Working in close cooperation with policy Directorates-General, the JRC addresses key societal challenges while stimulating innovation through developing new methods, tools and standards, and sharing its know-how with the Member States, the scientific community and international partners.

Serving society
Stimulating innovation
Supporting legislation

Publications Office

ISBN 978-92-79-47751-5
doi:10.2788/777426